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SILAGE PRODUCTION

E. S. HOPKINS AND P. O. RIPLEY

FIELD HUSBANDRY DIVISION
EXPERIMENTAL FARMS SERVICE

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LEGUME AND GRASS SILAGE. (SEE ALFALFA) PAGE 19

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Corn is the most important silage crop in Canada. It is grown extensively in Ontario, being adapted to a warm and humid climate. This photograph shows a forty acre field of corn on the Central Experimental Farm, Ottawa, where the average yield, over a period of 24 years, has been 16.4 tons per acre.

SILAGE PRODUCTION

BY

E. S. HOPKINS AND P. O. RIPLEY

INTRODUCTION

As the period of stable feeding in Canada frequently extends from six to eight months of the year the problem of supplying suitable feed for livestock is extremely important. Among the roughages used for this purpose, silage is employed very extensively.

Corn, sunflowers, sweet clover, red clover, oats and mixtures of oats and peas are the chief crops used for silage. Where corn can be grown satisfactorily it constitutes the most important silage crop. It produces a large yield and gives no difficulty in ensiling. Where corn cannot be grown, however, or where for any reason it is necessary to use some other crop, it is important to adopt the best possible ensiling practices.

This bulletin presents the results of many experiments conducted over a long period of years in regard to the suitability of various silage crops and the best methods of growing and ensiling them. The experiments have been conducted on both plot and field scale on the Dominion Experimental Farms located in various regions throughout Canada. On the Central Experimental Farm at Ottawa additional ensiling experiments have been undertaken during the last twenty years in small one-half ton experimental silos.

Information is given on the proper stage of maturity for cutting, the effect of wilting, the palatability and the chemical composition of some 19 different species of crops. A description is given of various types of silos and data are presented on the cost of producing and ensiling various silage crops.

In order to supplement the data secured from the experimental work on the Dominion Experimental Farms, information has been obtained from a large number of private farmers. These men very kindly gave their opinions on the advantages and disadvantages of the silo as well as on the methods used in growing and ensiling their crops. They contributed some very interesting data on the percentage of farmers in their districts who had discontinued the use of their silos and the reasons for this action.

HISTORY OF SILAGE

Little is known of the origin of the silo. The ancients were known to bury grain in underground pits in order to save it for future use or to hide it from their enemies. It is possible that the ensiling of crops may have been evolved through this practice of hiding grain and returning later to find it well preserved. Pliny A.D. 23-79 mentions this system of storing grain in the first century and called the pit or trench, "sirus," from which the word silo has developed.

Storing green fodder in pits or silos was not known until many years later. In 1786 Professor John Symonds of the University of Cambridge refers to the practice in Italy of "preserving the freshness and verdure of the leaves" by first spreading the green crop thinly on the ground in the hot sun for 3 or 4 hours, after which it was placed in wooden casks, pressed down closely and covered with sand. When taking the material from the casks, care was taken after removing the required amount to cover again immediately "lest the leaves be exposed to the air."

One of the early advocates of ensiling was Herr Adolph Reihlen, a sugar manufacturer and refiner of Stuttgart, Germany. Beet leaves, beet pulp and corn were ensiled, the results of trials being recorded in letters published in 1862 and 1865. So successful were the results with corn that the acreage was extended. In 1870 and for several years afterwards satisfactory silage was produced in a large trench silo.

In 1870 M. Vilmorin-Andrieux used the results of Reihlen's experiences together with that of others in a series of articles published in France in which the use of silage was recommended as a remedy for the effects of drought in France in that year. On the other hand, it is interesting to note that the ensilage process was introduced into England in 1879 as a means of storing crops in a year of high precipitation when field curing was carried on with great difficulty.

In 1877 M. Auguste Goffart, a French farmer whose name has been connected with the origin of silage by many writers, published his book "Manuel de la culture de l'ensilage de maïs et d'autres fourrages verts." This book embodies the experience of many years of study and is probably the first monograph on the subject ever published. Goffart has been named the "Father of Modern Silage" not because he was the first to use the method but because the published results of his experiences were responsible for popularizing the system and bringing it into general use. In 1879 Goffart's book was translated into English by J. W. Brown of New York City and did much to bring silage to the attention of American farmers.

The first comprehensive discussion of the subject in the United States is said to be that found in the Annual Report of the Department of Agriculture for 1875 which treats with "The French mode of curing forage." Possibly the first silo in the United States was that of Mr. Francis Morris of Maryland built in 1876. Some claim, however, that the first silo was built in Illinois in 1873. In 1889 L. H. Adams of Wisconsin reports that the probable number of silos in the United States had reached 2,000 while in 1933 there was estimated to be over 500,000 silos in the country. In 1891 King of Wisconsin published a report in regard to the examinations of 93 silos in several different states.

Among the first silos used in Canada is said to be that of Mr. V. E. Fuller of Oaklands Jersey Farm, near Hamilton, built in 1881. Dr. Jas. W. Robertson of the Ontario Agricultural College, Guelph, Ontario, was among the first Canadian investigators to study and report on silage. His bulletin, No. 32, "Ensilage," published in 1888 by the Ontario Department of Agriculture, deals with the matter in a very comprehensive manner.

In 1891 Mr. J. C. Langelier, in the province of Quebec published a book entitled "Guide pratique de l'ensilage à l'usage des praticiens." In this book considerable information is presented on the processes involved in the making of silage, the construction of the silo, the methods of filling, the crops which may be used, as well as on the methods of growing corn and feeding silage.

The Hon. Louis Beaubien, farmer and member of Parliament for Hochelaga, addressed a conference at St. Hyacinthe, Quebec, on January 13, 1886, on the subject "Le Silo et Le Pâturage." He pointed out that thousands of silos were then in use in France and Germany. He mentioned that 612 silos were in use in England in 1884 while in the following year the number had increased to 1,883. In 1892 the Quebec legislature ordered the printing of the report of the first annual convention of the "Ensilage and Economic Stock Feeding Association of Central Canada," held in Montreal, March 17, 1892. At this convention ensilage was thoroughly discussed.

Dr. J. H. Grisdale, agriculturist, and later Director of the Dominion Experimental Farms, published in 1900 bulletin No. 35, "The Stave Silo," which dealt chiefly with the construction of the silo. In 1910 another bulletin on "Growing and Using Corn for Silage" was written by Dr. Grisdale. This bulletin outlined the best methods of producing corn silage and fodder based on experiments conducted on the Dominion Experimental Farms throughout Canada.

Silage production is an important phase of Canadian agriculture. In the province of Ontario alone in 1931 there were 35,716 silos. This photograph shows a vitrified tile silo (right) and a cement block silo (left) on the Central Experimental Farm, Ottawa. Silage is good insurance against winter feed shortage.

IMPORTANCE OF SILAGE IN CANADA

Number of Silos in Canada

The number of silos in the various provinces of Canada, as reported in the Dominion of Canada Census of 1931, is presented in the following table.

TABLE 1—NUMBER OF SILOS IN CANADA

Province	Number of silos	Province	Number of silos
Prince Edward Island	44	Manitoba	468
Nova Scotia	277	Saskatchewan	544
New Brunswick	169	Alberta	433
Quebec	6,138	British Columbia	2,038
Ontario	35,716		
		Total in Canada	45,827

The total number of silos reported for the whole of Canada was 45,827. These silos were located on 42,522 farms indicating that there was a small percentage of farmers who had more than one silo.

The largest number of silos was found in the province of Ontario where 78 per cent of all the silos in Canada are located. Quebec has the next largest number with 13 per cent while British Columbia stands third with 4 per cent. In the other provinces of Canada the silo is relatively unimportant.

The reasons for the prominence of the silo in Ontario and in parts of Quebec may be attributed to the system of mixed farming which is practised in these regions as well as to the suitability of the corn crop which produces such a large yield per acre and is so well adapted for ensiling.

Acreage of Grain and Forage Crops in Canada

In order to indicate the relative importance of the various field crops in the different provinces of Canada the acreages devoted to the most important crops are presented. It is impossible to estimate the acreages of the various crops which are ensiled for the reason that several crops are used for this purpose and none is specifically designated for silage in published reports. The chief crop ensiled in Ontario is corn but in some other provinces red clover, sweet clover, or oats are used extensively. The following table shows the acreages of grain, hay, pasture, fodder corn, turnips, mangels, etc., as reported by the Dominion of Canada census of 1941.

NUMBER OF FARMS AND ACREAGES OF PRINCIPAL CROPS IN CANADA
1941 CENSUS

Province	Number of Farms	Grain	Hay	Pasture			Fodder Corn	Turnips Mangels etc.
				Improved	Natural	Total		
Prince Edward Island	12,234	185,603	219,330	237,062	80,604	317,666	602	10,743
Nova Scotia	32,963	91,841	393,987	175,283	732,831	908,114	644	9,985
New Brunswick	31,881	236,204	561,813	292,887	364,481	657,378	1,143	10,575
Quebec	154,629	2,175,406	3,952,781	2,693,337	2,442,431	5,135,768	67,733	33,571
Ontario	178,169	4,718,227	3,710,239	3,228,070	3,966,354	7,184,424	295,057	63,254
Manitoba	58,022	5,720,844	458,657	454,799	4,821,661	5,276,460	36,874	2,626
Saskatchewan	138,703	19,147,115	563,103	782,926	19,783,222	20,566,148	9,431	1,267
Alberta	99,716	11,164,042	848,862	630,564	18,723,101	19,353,665	3,246	2,605
British Columbia	26,372	197,949	290,764	171,619	1,828,365	1,999,984	4,615	3,536
TOTAL IN CANADA	732,715	43,637,231	10,999,536	8,666,547	52,743,060	61,409,607	419,345	138,162

Pasture occupies the largest acreage of any farm crop in Canada, with 61,409,607 acres in 1941. However, natural or unimproved pasture constitutes the principal proportion of this acreage, the majority of which is located in the provinces of Saskatchewan and Alberta. Grain occupies the largest acreage of cultivated land, there being 43,637,231 acres in 1941 of which 36,032,001 are in the three Prairie Provinces.

Turnips and to a lesser extent mangels are grown as a succulent crop in the three Maritime Provinces, where corn is not well adapted. In all the other provinces corn is grown more extensively than roots. The acreage devoted to fodder corn in Canada in 1941 was 419,345 acres, the majority of which was grown in Ontario and much of it used as silage. While no figures are available, there is also a considerable and increasing use of grass and legume crops for silage.

PROCESSES INVOLVED IN THE CONVERSION OF GREEN FODDER INTO SILAGE

Several factors are involved in the changes which take place from the time green fodder is placed in the silo until the ensilage process is complete. The more important factors are the respiratory action of the plant with the resulting development of heat, the activity of plant enzymes and the action of bacteria and fungi.

When green plant tissue is placed in the silo, or in any closed container, it continues to live for a certain period of time. Respiration is maintained, therefore, and some of the carbohydrates such as sugars and starches, combine with atmospheric oxygen to be converted chiefly into carbon dioxide and water. In the latter stages of the respiratory process, however, when the supply of oxygen is becoming exhausted, small amounts of other compounds such as ethyl alcohol, acetic and lactic acid may be found. These changes are accompanied by an increase in heat and a certain loss of important food nutrients, the loss in dry matter averaging approximately fifteen per cent. Since oxygen is necessary in the changes which take place in the silo, the extent to which the process is carried on depends quite largely upon the supply of air contained in the silage material. The air supply in turn depends to quite a considerable extent upon the maturity or succulence of the crop. The effect of these varying condition on the quality of the silage is discussed in the chapters dealing with the ensiling of the various crops.

Enzymes are present in all fresh plant materials and after the death of the plant cells these enzymes continue to act. Their chief function is the breaking down of the proteins of the plant with the formation of simpler and more soluble products. The process is similar to the digestion process which takes place in the intestinal tract of an animal. It is questionable if this process constitutes an advantage from a nutritional standpoint.

About the time the activity of the living plants begins to diminish in an insufficient supply of oxygen, the activities of lower forms of life such as moulds, yeasts and bacteria increase. In good silage moulds do not function except for a few hours because of the absence of air. In very dry crops more air is present and moulds develop to a greater extent. Yeasts may continue to grow for a longer period than moulds but they, too, last a comparatively short time, probably a few days.

Bacteria play an important part in the ensilage process. Many bacteria will not live under conditions existing in the silo while others find these conditions ideal, the cell sap with its high content of sugars, proteins and salts furnishing excellent food for the development of the bacteria. Bacteria bring about many changes in the silage, the chief being the development of organic acids. Some of these acids, as previously mentioned, develop on account of the

incomplete oxidation of the carbohydrates during the respiration of the plant cells at the time the oxygen supply is becoming exhausted. Bacteria are largely responsible, however, for the development of these substances. In good silage, lactic acid predominates but acetic acid and a smalll amount of propionic acid are also found. Butyric acid, the very offensive smelling acid found in sour and spoiled silage, should be entirely absent in well made silage. The action of bacteria ceases when conditions unfavourable for their development are produced, due to changes in food conditions and to the accumulation of the fermentation products. Following the cessation of bacterial action the process

Over 500 farmers throughout Eastern Canada contributed information pertaining to certain aspects of silage production which is presented on pages 11 to 16 of this bulletin. The stave silo is used more extensively than other types.

reaches a state of comparative equilibrium and the silage remains in this preserved state with little or no change for an indefinite period, instances of at least four years having been observed.

The moisture content or succulence of the crop plays an important part in the quality of the silage. In experiments conducted on the Central Experimental Farm at Ottawa the production of good or bad silage can usually be traced to the amount of moisture contained in the ensiled crop. Too dry material invariably results in mouldy silage. The presence of too high a moisture content produces sour, rotten silage. For best results different crops require different moisture contents. In general, however, a moisture content between 65 and 75 per cent will produce a good silage.

Amos and Woodman, in Bulletin No. 37 of the British Ministry of Agriculture, divide silages into five distinct types based on the temperature reached in the silage process, the temperature being controlled quite largely by the moisture content of the silage. These five types embrace:—

1. Sweet, dark brown silage produced from a comparatively dry crop where conditions are such that fermentation is facilitated by the presence of sufficient air so that the temperature rises above 113° F. This makes good silage which is relished by cattle but is produced by excessive fermentation with a considerable loss in digestible nutrients. For this reason it is not generally recommended.

2. Acid, light brown or yellow brown silage, a good silage made from material with a dry-matter content of 25 to 30 per cent which allows for temperatures of from 86° to 104° F. with a pleasant acid smell. It is the type of silage which is recommended.

3. Green fruity silage is made from immature succulent material high in moisture and is a silage in which the temperature seldom goes above 86° F. It is characterized by a fresh fruity odour and green to olive green colour. Considerable loss occurs with this silage due to the draining away of the juices. It makes a palatable silage which is readily eaten by cattle but is more difficult to make than other types and is not generally recommended.

4. Sour silage has a dark brown or olive brown colour with a pungent and very unpleasant smell due largely to the presence of butyric acid. It is made from very immature and succulent crops or it may be found in the bottom of the silo where moisture accumulates. It is also associated with oats, peas and vetch silage where the growing crop has lodged badly and become partially rotten. This is a very poor type of silage.

5. Musty silage usually occurs following the ensiling of crops which are too dry thereby allowing the presence of an excessive amount of air in which moulds develop. It is found, also, on the top of silos, or near cracks in stave silos where air has ready access. It occurs sometimes in patches throughout the silage mass.

Considerable judgment is necessary to ensile crops at the proper stage of maturity and succulence in order to make the highest quality of silage and to avoid, in some cases, instances of complete failure where the silage is unfit for feed.

WHAT THE FARMER THINKS OF SILAGE

In order to secure information in addition to that obtained from the experiments and experience of the Dominion Experimental Farms, the opinions of a large number of representative farmers in Eastern Canada were secured during the winter of 1932-33. Most of these farmers owned a silo but others were included, who grew corn as fodder or produced root crops. It is felt that this investigation has contributed much useful information from both owners and non-owners of silos and has shown the extent and reasons for the discontinuance of the use of the silo which has become rather prevalent in some districts. As very complete replies were given in the questionnaires received from 573 farmers it is believed that the information secured is fairly representative and reliable.

The average size of the farms studied was 182·4 acres, of which 120·8 acres were under cultivation. The acreages of grain, hay and pasture were approximately equal, being 41·1, 41·6 and 42·1 acres, respectively. The following table shows the average acreage and yield of the various silage and root crops on the farms where these crops were grown.

TABLE 3—ACREAGES AND YIELDS OF SILAGE AND ROOT CROPS

Crop	Acreages		Yield	
	Acres per farm	Number of farms	Yields per acre (tons)	Number of farms
Corn for silage	8·8	426	11·6	317
Corn for fodder	2·9	159	9·6	112
Sunflowers for silage	3·3	7	10·9	6
Oats and peas for silage	5·3	35	3·6	27
Red clover for silage	7·5	9	–	–
Sweet clover for silage	8·7	31	–	–
Mangels	1·4	267	17·1	214
Turnips	1·7	364	17·8	312

Corn was pre-eminently the most important silage crop grown on these farms. Other crops were used for this purpose but only to a very slight extent. Turnips and mangels were grown on a large number of farms although on quite small areas, only 1·7 and 1·4 acres, respectively.

INFORMATION REGARDING THE SILO

Size and Type of Silos

Ninety-five different sizes of silos were reported from 476 farms. These silos ranged in diameter from 8 feet to 25 feet, and in height from 15 to 55 feet. The most popular size of silo was 12 feet by 30 feet with a capacity of approximately 60 tons.

The stave silo was by far the most commonly used there being 386 silos or 69 per cent of this type. The cement silo was second with 127 or 23 per cent. There were 28 frame silos, 9 cement block, 5 tile, 1 brick, 1 steel, 1 pit and 1 trench silo.

Building Cost

The average cost of the silos, based on 359 replies, was $263. The cost of material for building, according to 227 replies, was $192.50 and the cost of labour $43.50. The stave silos cost $201.22 for material and $29.20 for labour, a total of $230.42. Cement silos with an average capacity of 108 tons cost $164.55 for material and $101.90 for labour, a total of $266.45.

The average age of 343 silos was 14·9 years. The oldest silo reported in this survey was 42 years. It was a stave silo built in 1891 and was still in use.

Unused Silos

What farmers think of the value of their silo may be judged fairly accurately by the number who still use it as compared with those who have discontinued its use. If a man no longer continues to use his silo, after having spent considerable money in its construction, it is useful to know the reasons for this change.

Among the silo owners reporting in this study 458 or 94·4 per cent, still continued to use their silos while only 27 owners, or 5·6 per cent, had discontinued their use. Some farmers reported, however, that in certain districts as many as 25 per cent of the owners had discontinued the use of their silo. It may be mentioned, nevertheless, that some of these men, after experiencing a feed shortage without the silo, returned to the use of it again.

REASONS FOR DISCONTINUING THE USE OF THE SILO

Why do so many farmers no longer use their silos? The answer will be found in the following list of reasons which 249 farmers assigned. It is significant that 76 per cent of these replies indicated that directly or indirectly the high cost of the silage was the most important reason.

TABLE 4—REASONS FOR DISCONTINUING THE USE OF THE SILO

Causes for discontinuing use of silo	Number of farmers who assigned these causes	Causes for discontinuing use of silo	Number of farmers who assigned these causes
High cost of filling	73	Laziness	8
High cost of labour	67	Poor quality of silage	7
Silo blown down: replacement too expensive	14	Other feeds cheaper	7
Poor yields of corn	13	Farming not profitable at present	6
Herd too small now	11	Filling machinery too dear	6
Changing feeding conditions	10	Other crops more profitable	4
Silage crops replaced by alfalfa	9	Lack of working capital	3
Silo rotted; replacement too expensive	9	Corn borer	2

Spoiled Silage

It is evident from this study that quite an appreciable number of farmers have experienced difficulties at various times from spoiled silage. Out of 435 replies, 152 had experienced trouble with mouldy silage, 93 reported some rotted silage and 199 had silage frozen. Stock had been injured in 19 instances by spoiled silage.

Size of Herd to Warrant a Silo

In reply to the question "what size of herd warrants a silo" the average of 387 replies set the minimum size of the herd at 13 animals.

Advantages of the Silo

The following advantages of a silo were advanced by 589 farmers. They indicate the relative importance attached by these men to the various uses for which the silo serves.

TABLE 5—ADVANTAGES OF THE SILO

Advantages	Number of farmers who assigned this advantage	Advantages	Number of farmers who assigned this advantage
1. Provides palatable and succulent feed for winter	168	8. Provides succulent feed when pastures fail	31
2. Provides more feed from a small acreage	71	9. Improves condition of stock	27
3. Increases livestock carrying capacity of the farm	56	10. Less waste	19
4. Increases milk production	52	11. Controls weeds and cleans land	14
5. Saves storage space	47	12. Facilitates winter dairying	14
6. Saves grain and hay	41	13. Helps control corn borer	9
7. Cheapens maintenance and cost of production	34	14. Wet seasons do not interfere with harvest	6

Disadvantages of the Silo

The most important disadvantage of the silo is the high cost of producing silage. It is significant that 257 of the replies to the question give this cause as the chief factor against the silo. It is consistent, moreover, with the reason assigned by many farmers for discontinuing the use of the silo. Certainly, the introduction of any method which would reduce the cost of production would contribute greatly toward making this method of storing crops more popular.

TABLE 6—DISADVANTAGES OF THE SILO

Disadvantages	Number of farmers who assigned this disadvantage	Disadvantages	Number of farmers who assigned this disadvantage
1. Cost of filling	99	7. Initial cost of equipment too high	11
2. Cost of labour	87	8. Freezing of corn in field and in silo	6
3. Filling interferes with other fall work	24	9. Corn depletes soil fertility	5
4. Special machinery too expensive	17	10. Silage spoils	5
5. Cost of production too high	16	11. Short life of silo	3
6. Unsuitable soil and climate	11		

METHODS USED BY FARMERS IN GROWING CORN

As corn is the most widely used silage crop in the warmer districts of Canada where this crop succeeds it was thought useful to learn the practices most commonly followed. For further information in this regard, however, it would be advisable to consult the section on page 25 of this bulletin dealing with the best methods of production.

Where Corn is Grown in the Rotation

Eighty-three per cent of the farmers replying to this questionnaire grew corn after hay or pasture while 17 per cent grew it after grain.

Manure for Corn

Farmyard manure is usually employed for the benefit of the corn crop. The average rate of application, based on 493 replies, was 14·5 tons per acre. The largest number of farmers, 38 per cent, applied the manure in the spring, 31 per cent applied it in the winter, 15 per cent in the fall and the remainder at varying times whenever it was convenient. About equal numbers applied the manure before ploughing as applied it afterwards. Over twice as many used fresh manure as compared with those who allowed it to rot. The great majority, 62 per cent, fall ploughed for corn, 21 per cent spring ploughed and 17 per cent ploughed both in the fall and spring.

Commercial Fertilizers

Commercial fertilizers are used to quite an appreciable extent by farmers growing corn. One hundred and seventy-two farmers, or 44·5 per cent, used these materials at an average rate of 431 pounds per acre. Fifty-one different and widely varying commercial formulae or mixtures were used. The 4-8-10 fertilizer was the most widely used, 54 farmers applying this mixture, 26 used a 2-12-6 and 24 used an 0-16-0 fertilizer. The other mixtures were used to a much smaller extent.

Cultivating and Hoeing

Corn was cultivated 4·5 times and hoed twice as based on the average of 558 replies. This work was claimed to be necessary in order to control weeds.

Damage by Crows

Crows have proved troublesome to over one-half of the corn growers. The most common methods of combating these birds in the order of their greatest frequency of use were tar, poison, shooting, scarecrows and deep seeding, the first three methods being the most generally used. Other methods used to a much smaller extent were kerosene, turpentine, early seeding, sulphur, dogs, kerosene and sulphur, traps, and burning gunpowder.

METHODS OF ENSILING

Size of Crew

The average crew consisted of slightly over 10 men and 4 teams, 62·6 tons being ensiled per day.

Custom or Privately Owned Machines

Two hundred and seventy-three farmers used their own machines for filling while 187 used custom machines. The average price charged for a custom machine, including engine, blower and attendant, was $17.80 per day. The great majority of the machines were of the regular ensilage cutter type with blower but a few used a cutting box with a carrier attachment.

Methods of Ensiling

The large majority of farmers tramped the silage when filling the silo. However, 49 men did not follow this practice, claiming good results but 6 reporting unsatisfactory silage. Nineteen were of the opinion that the silo held just as much when the silage was not tramped as when tramped while 16 were of the opposite opinion.

Ninety-three farmers reported ensiling stooked corn in the winter. Water was added at the rate of 223 pounds per ton of corn. Sixty-eight farmers reported good silage following this procedure, 14 had fair silage and 23 had poor silage. Further information on this subject will be found on page 33 of this bulletin.

Gas in the Silo

Instances of men being overcome with gas in the silo were reported by 10 farmers while 353 replied that they had never known any cases of this trouble. Care should always be exercised, however, to avoid entering partly filled silos which have been left for a few days without first starting the blower in order to provide for the circulation of fresh air.

HARVESTING FODDER CORN

While many different methods are employed to cut corn the great majority use the corn binder. Quite a number, however, use the sickle while a few use the hoe, grain binder, scythe, mower or sled cutter.

Fodder corn is usually left in the stook in the field for about three months although many leave it for only two months and a few for only three to six weeks. In regard to storing this corn, 60 stored it in an upright position in the barn, 59 drew it from the field as required and 18 stooked it in piles near the barn. The majority of growers fed the fodder corn in the stalk but quite a number cut it before feeding.

ROOT VERSUS SILAGE CROPS

While the relative advantages of roots and silage cannot be determined from the results of this questionnaire, it is interesting to observe the points of superiority claimed for these two different feeds. The reason most frequently given in favour of roots was that they were considered more nutritious than corn but, on the other hand, quite a number of corn growers claimed the reverse to be true. Roots were said to improve the condition of the livestock, were better for young and fattening stock and could be used as fall feed to better advantage. They were reported to be cheaper than silage but this point was the chief reason assigned by the majority of the farmers in favour of silage. Roots were claimed to be more easily harvested, were not damaged by frost in the field and less subject to it in storage as well as being more adapted to a wider range of climate. The relative advantages of roots and silage are discussed more fully on page 53 of this bulletin.

Experiments have been conducted on the Central Experimental Farm, Ottawa, in small silos of one-half ton capacity as shown in the photograph, in order to determine the best methods of ensiling various crops. Nineteen different crops, together with many mixtures to improve the quality of the silage, have been studied.

EXPERIMENTS WITH SILAGE CROPS ON DOMINION EXPERIMENTAL FARMS

The information presented in this bulletin pertaining to cultural methods, rotations, fertilizer treatments and cost of producing various silage crops is based upon the results of experiments conducted from 1886 to 1943, on the Dominion Experimental Farm at Ottawa and on various Branch Experimental Farms throughout Canada.

Experiments on a wide variety of methods of harvesting and ensiling various crops have been conducted by the Field Husbandry Division of the Central Experimental Farm, Ottawa, since 1924. Twenty-four small experimental silos, 3 feet in diameter, 6 feet high and holding approximately 1,000 pounds of green material, have been used for these experiments. The silos were of wooden construction with narrow wooden staves of tongued and grooved pine drawn together by a number of round iron hoops.

Drainage from the silo was provided through four small holes bored in the side near the bottom. A galvanized iron pan was placed under the silo and the liquid drained into a covered, galvanized container. When filling the silo the material was thoroughly tramped and covered with a tight-fitting, felt-edged lid which was weighted with 500 pounds of stone or in some instances with a thin layer of straw covered with an equivalent 500 pounds of soil. While this arrangement did not completely eliminate some spoiled silage at the top of the silo it was apparently sufficient to provide conditions which produced silage equal to that found in large silos. Naturally, the percentage loss of spoiled silage was greater in the smaller silos but, after the top layers had been removed, the quality of the silage was comparable with that obtained from large silos.

Careful notes were taken at the time of ensiling on the stage of maturity, amount of wilting and other characteristics of each individual silage crop. Moisture determinations of the silage were made and the amount of liquid which drained from each silo was recorded. When the silos were opened approximately six months later, further observations were again made on the colour, odour and quality of the silage. Chemical analyses were made, through the co-operation of the Division of Chemistry, while the palatability of the silage was determined by feeding it to dairy cows provided through the co-operation of the Division of Animal Husbandry.

SILAGE CROPS

Corn, sunflowers, red clover, sweet clover, oats, and mixtures of oats, peas and vetches are perhaps the most generally grown crops for silage. Experiments conducted by the Field Husbandry Division of the Central Experimental Farm, Ottawa, show that other crops may also be used satisfactorily for this purpose. Little trouble is ever experienced in ensiling corn and sunflowers, as these crops are well adapted to this type of storage. Cereal crops, however, are more difficult to ensile while legumes, especially alfalfa, also present difficulties when not properly ensiled. Legume crops contain a comparatively high percentage of protein with a low percentage of carbohydrates which, unless certain precautions are taken in handling, promotes the development of undesirable bacteria. This causes decomposition resulting in a poor quality of silage. Extensive experiments have shown, however, that legume crops, if properly handled, will produce excellent silage.

Cultural, Rotational and Fertilizer Practices Applicable in Humid Regions

Owing to the wide variations throughout Canada in soil and climatic conditions, it is not possible to outline practices which will apply in all districts. Inasmuch as silage production is more prevalent in the humid regions of Eastern Canada and British Columbia, the cultural, rotational and fertilizer practices outlined under the various crops, apply only to these parts of Canada.

However, the information relating to types of silos and the methods of ensiling various crops, applies to the whole of Canada. Moreover, information on the adaptability of the silo and some details on the production of various silage crops are presented in the section of the bulletin dealing with the adaptability of the silo to different parts of Canada. This data together with that outlined under each specific silage crop, will provide useful information applicable throughout Canada.

ALFALFA

Alfalfa is indigenous to the region about the Mediterranean Sea. It is probable that the seed was distributed by traders as early as 4000 to 7000 B.C. The first documentary evidence of the existence of alfalfa under cultivation is in a Babylonian text written about 700 B.C. Alfalfa was the forage fed to the animals of the army of Xerxes, King of Persia, in 485-465 B.C. in his wars with the Greeks. The introduction of alfalfa into Italy and its rapid spread by the Romans throughout their empire, beginning about the second century B.C., is responsible for its distribution in many parts of the Old World. It became established in Germany, France, Spain and England as early as the 16th century. It was introduced into South America from Spain and from Chili to California in 1850, according to University of California Circular 87, "Alfalfa."

Alfalfa is widely used as a hay and pasture crop. As a hay crop it has few if any rivals. It contains a large percentage of protein and is highly valued as a feed for dairy cows and other classes of livestock. In recent years the crop has been artificially dried and ground into alfalfa meal which is used as a high protein concentrate for poultry and livestock. Unless winter-killed or crowded out by couch grass, alfalfa will produce good crops without reseeding for many years. Its deep and extensive root system makes it capable of producing good crops even under the severe summer drought conditions sometimes experienced in Eastern Canada. Alfalfa is probably the highest yielding hay crop. The average yield on the Central Experimental Farm, at Ottawa, over a period of 20 years, has been 3·54 tons of hay per acre, or 11 tons when cut green for silage.

As a pasture crop alfalfa is excellent but care must be taken to avoid grazing so closely as to injure the crown of the plant. Care must be taken, also, when animals are first grazed on alfalfa or bloating is liable to occur. Animals should be given other feed before being first allowed to graze alfalfa. Extra care should be taken in grazing wet or frozen alfalfa, and to avoid grazing if the crop is in flower. If properly handled alfalfa will produce excellent silage. Being a legume it is an ideal soil improvement crop.

Rotation, Fertilizer and Cultural Practices for Alfalfa

In the humid regions of Eastern Canada and British Columbia alfalfa follows a grain crop in the rotation. It is usually seeded with a nurse crop of wheat, barley or oats. As alfalfa is a perennial crop it may be grown continuously if desired as long as it continues to produce satisfactory yields. It may be grown in a regular farm rotation, however, and when this is done it exerts a favourable influence upon the yields of suceeding crops.

When seeding down with a nurse crop of wheat, oats or barley, it is desirable to use a fertilizer which will benefit both the nurse crop and the alfalfa. On heavy soils the recommended fertilizer for the purpose is a 2-12-6, and on lighter soils a 2-12-10. The rate of application should vary, according to previous manurial treatments and the level of fertility of the soil, from 200 to 400 pounds per acre, drilled in with the grain.

Alfalfa will also respond to applications of mineral fertilizer applied directly to the crop every 2 or 3 years. For this application 300 to 500 pounds of 0-14-7 fertilizer is recommended on heavy soils and a similar amount of 0-12-10 on light soils. On some soils the use of superphosphate alone will be sufficient.

The cultural practices for the growing of alfalfa with a nurse crop of grain are the same as those outlined on page 36 for the production of oats. Where alfalfa is grown on any land for the first time the seed should be inoculated with legume bacteria. The same bacterial culture is used for alfalfa as for sweet clover. If a sweet clover or alfalfa crop has been grown previously with success on the field, the soil itself is sufficiently inoculated to produce alfalfa without further inoculation of the seed.

If pure alfalfa is to be grown it should be seeded at the rate of 15 pounds per acre. It is advisable, however, under most conditions to add a small amount of alsike and timothy so as to provide some growth if the alfalfa becomes killed. A mixture of 15 pounds of alfalfa, 2 pounds of alsike and 3 pounds of timothy per acre is very satisfactory. If the success of the alfalfa is somewhat doubtful the addition of a few pounds of alfalfa to the ordinary hay mixture proves very successful. A recommended mixture consists of 6 pounds red clover, 2 pounds of alsike, 6 pounds of timothy and 6 pounds of alfalfa per acre. If the alfalfa grows well it will probably dominate the mixture and, after the first year, becomes an almost pure stand of alfalfa.

Grimm or Ontario Variegated are the recommended varieties. Canadian grown seed should be secured as it is more hardy and less susceptible to winter injury.

Legume and Grass Silage

The most extensive use of clover for silage in Canada is in the Fraser River Valley of British Columbia. The heavy rainfall in that region makes the curing of the first cut of clover for hay very difficult and hence has given rise to the general practice of ensiling this crop, a practice which has been followed successfully for many years. Most farmers use no preservative of any kind and are able to produce a good quality of silage. More recently, however, owing to the publicity given to the use of preservatives, there has been an increase in the use of these materials. In other parts of Canada where there is serious difficulty in making hay on account of heavy rainfall, fog, excessive dew or little sunshine, the practice of ensiling grass and legumes is arousing interest and to some extent is being adopted. In these regions this practice would undoubtedly offer considerable promise.

Detailed information in regard to methods of making legume and grass silage will be found in this bulletin, especially in the following section entitled Harvesting and Ensiling Alfalfa, and also in the sections relating to other legume and grass crops.

Harvesting and Ensiling Alfalfa

Under average conditions in Eastern Canada two cuts of hay per season may be harvested with safety. A third cut is sometimes taken but is not generally advisable since it tends to reduce the vigour of the plants and makes them more susceptible to winter injury. When used for hay alfalfa is cut when it is about one-tenth in bloom. It is mowed one day, raked into windrows the day following, cocked and allowed to remain in the field until dry enough to draw to the barn. Where weather conditions are favourable the crop will dry in the windrows and may be loaded with a hay loader. Some difficulty is experienced in curing heavy crops of alfalfa hay because of the rather coarse, succulent stems which require much longer to dry than the leaves. This may result in many leaves being lost unless considerable care is exercised in handling, although alfalfa is not such an offender in this respect as sweet clover.

Alfalfa can be made into excellent silage, but it requires more care when ensiling than some of the other crops. Unlike corn which is an ideal crop to ensile, alfalfa contains a relatively low percentage of carbohydrates (starch, sugars, etc.) and a high proportion of protein. In a crop like corn which contains a large amount of carbohydrates, fermentation processes and bacterial action are carried on at a fairly rapid rate. On the other hand, in crops like alfalfa or red clover in which the protein content is much higher the development of lactic acid is slower, and unless suitable conditions are provided other types of bacteria act on the proteins, breaking them down into putrid, vile-smelling substances which may render the silage unfit for feed.

Importances of Moisture Content

The moisture content of the crop is an important factor in promoting the proper silage-making process. While it is true that alfalfa can be ensiled under climatic conditions which would make haying impossible, it should be remembered that a more satisfactory silage can be made from the crop if ensiled under favourable weather conditions and at the proper moisture content. If ensiled when too dry it is likely to mould and if too wet the development of rotten substances may be encouraged. Experiments show that a moisture content of approximately 70 per cent gives the best results. It is rather difficult to estimate just when the crop to be ensiled contains the proper amount of moisture. This is a matter which requires considerable experience and judgment. A number of observable factors may serve as a guide. It is often possible to tell by the feel of the crop when twisted in the hands or by the feel and appearance of the cut silage whether or not it contains the proper amount of moisture. If alfalfa is cut when quite immature, previous to the bud stage, it almost invariably contains too much moisture and should be wilted for at least 5 hours. If wilting is carried too far, the material may become too dry and mouldy silage will result. If the silage is too moist another practical way of reducing the moisture is to mix 200 to 300 pounds of chopped dry hay with each ton of silage. Probably the most satisfactory guide is to cut the alfalfa just as it reaches full bloom and ensile as soon as possible with no outside moisture from dew or rain. This usually provides about the proper moisture content and results in the production of good quality silage.

Unless proper methods are followed alfalfa is one of the most difficult crops to ensile. If ensiled when the crop is one-tenth in bloom, as recommended for hay, the silage is very liable to be absolutely unfit for feed. It is essential to delay ensiling until it has reached the full-bloom stage when excellent silage is produced. Wilting up to five hours somewhat improves the quality. Additions of dilute acid in proper proportion, or carbohydrate materials, such as green corn, timothy, or molasses may also be used to improve the quality.

Carbohydrates are Necessary for Good Silage

A relatively high carbohydrate content facilitates the making of good silage. With alfalfa the proteins decrease with the maturity of the crop while the carbohydrates increase. Chemical analyses show that alfalfa in the bud stage contains 24·7 per cent protein on a dry-matter basis and 5·50 per cent

total sugar, while in the full-bloom stage it contains 20·3 per cent protein and 7·90 per cent total sugar. The increase in carbohydrate and decrease in protein at the later stage of maturity is a very important factor partly accounting for the greater ease of making good silage at this stage. It is some advantage to have a silage with the highest amount of protein possible since it is a very valuable food constituent. The greater assurance of making a good quality silage with the alfalfa in full bloom, however, more than offsets the disadvantage of a slight decrease in protein. Even at this stage, alfalfa silage contains more than double the protein found in good corn silage.

The Addition of Molasses

Although good silage may be made from alfalfa cut in the full bloom stage without adding any preservative material, it is advisable under certain conditions to add carbohydrate materials to encourage the development of lactic acid. One of the most suitable forms in which such material can be added is in molasses. This material is highly concentrated, containing approximately 55 per cent of sugar which is readily convertible into lactic acid by fermentation. When very young grass or legumes are ensiled it is essential to add some such material to make good silage. When the crop is wet by rain or dew, molasses will also help preserve it. The recommended amount of molasses to use ranges from 80 pounds per ton of crop, when very immature or damp material is used, to 40 pounds where the more mature crop is ensiled. One gallon of molasses weighs approximately 12 pounds. Molasses may be added by sprinkling it on the surface of the silage as the crop is being ensiled, or a more convenient way is to apply it from a barrel on a raised platform at the side of the ensilage cutter. A hose or pipe from the bottom of the barrel may be attached to convey the molasses from the barrel into the fan box of the cutter. A tap should be placed conveniently in the pipe so that the man feeding the cutter can adjust the rate of flow of molasses as desired. It is usually necessary, particularly in cool weather, to mix equal parts of molasses and water in order to allow the molasses to flow readily through pipe or sprinkler.

The Use of Other Carbohydrate Materials

Other carbohydrate materials have been found to be helpful when added to legumes for silage. Where convenient, mixing equal parts of corn and alfalfa will often improve the nutritive value and quality of both crops. Usually, however, third cut alfalfa would have to be used and it may be dangerous to cut alfalfa so late in the season because of the greater possibility of damage from winter killing. Such a method could be used satisfactorily where the alfalfa land is to be ploughed after harvesting the crop. One part of fairly mature green grass, such as timothy or couch grass, mixed with three parts of legume, will facilitate the making of good silage. Mixing 80 to 100 pounds of barley meal or corn meal with each ton of legume increases the carbohydrate content of the silage and improves the quality. Soaking the meal with water 2 days previous to application initiates fermentation and the slightly fermented material increases the speed of the fermentation process in the silo, and improves the silage.

Apple concentrate may be used instead of molasses for treating legume silage if the price per gallon is comparable. It contains approximately 52 per cent total sugars, as compared with about 55 per cent in molasses. Other substances are also present in apple concentrate, including malic acid, tannin and pectin. Experiments indicate very similar results in the quality of silage following treatment with molasses or apple concentrate. If there is any difference the palatability seems slightly superior when the apple concentrate is used. It is unlikely, however, that this material will be available on account of its higher price.

The Use of Acids in the Treatment of Legume Silage

Various acids have been suggested and used fairly successfully as preservatives, particularly for high protein silages. One of the leading exponents of the acid treatments has been Dr. A. I. Virtanen of Finland who recommended a solution of hydrochloric and sulphuric acid which has been patented in several countries and sold under the name of the A.I.V. process. The use of phosphoric acid has been recommended by a number of investigators. The theory of the use of acids is that it is not necessary to wait for the development of lactic acid to preserve the ensiled crop if acids are added, as they act immediately, halting the fermentation process and enzymatic action, preventing the losses resulting from these processes and preserving the crop largely in its natural state. By using phosphoric acid, mineral phosphate which is so essential in proper animal nutrition, is also added.

A considerable amount of experimental work has been done at the Central Experimental Farm, Ottawa, to determine the value of these acids, Undoubtedly their use improves the quality and reduces the loss of legume silage which otherwise occurs when this type of crop is ensiled in the ordinary way. The acid treatment, however, has not become popular in Canada. There are several reasons for this. First, the cost is relatively high. For instance, if 16 pounds of phosphoric acid are applied per ton, at an approximate price of 8 cents a pound, the cost will be $1.28 per ton. Second, acids particularly sulphuric acid and hydrochloric acid are rather inconvenient to apply because of their burning effect on clothes and equipment. Third, there is a reticence on the part of livestock men to apply strong acid to silage because of the probable bad effect which it might have on the digestive system of the animal. In connection with the latter, it is recommended that one pound of a mixture of 70 per cent lime and 30 per cent sodium carbonate be added to each 250 pounds of acid treated silage. Where this has been done no ill effects from the acid have been noticed.

Salt and Lime

The addition of salt or hydrated lime has not resulted in any observable effect on the quality of silage. Salt has been added to silage in amounts varying from 5 to 15 pounds per ton of silage and while none of the rates has affected the quality of the silage the larger amounts had a tendency to produce a laxative effect on the animals.

Lactic Acid Cultures

Certain lactic acid cultures have been prepared from sour milk or buttermilk with a view to adding lactic acid and lactic acid producing bacteria. In trials made at Ottawa little or no benefit was derived from treatments with these products. There is probably a sufficient number of the desirable bacteria present in a normal crop to promote the conversion of sugars into lactic acid and thus the adding of additional numbers may tend to be superfluous.

ALSIKE

Alsike is a native of Europe and Asia where it has been cultivated since the tenth century. It was introduced into England from Sweden in 1834 and was brought to North America about 1854. It is finer in growth and produces more leaf in proportion to stem than red clover. Where the latter crop does well alsike cannot compete with it from the standpoint of yield. However, alsike will grow under a much wider range of conditions being much less sensitive to acid soil conditions. It prefers a cool, moist climate and a comparatively heavy soil. It is usually sown in a mixture with timothy and clover except where it is grown for seed production. As it is a perennial plant surviving in the land for several years, it is valuable in mixtures as a pasture crop. It is grown extensively in Eastern Canada and British Columbia but is not adapted to the Prairie Provinces.

Alsike produces excellent silage. It should be cut in the full-bloom stage and ensiled immediately. It may be ensiled even without cutting with the ensilage cutter but special care should be exercised under such conditions in tramping the silage thoroughly in the silo. In one experiment alsike which was very heavily infested with ox-eye daisy was ensiled when both crops were in the full-bloom stage. A very good silage was produced. It is apparent, therefore, that alsike may be successfully used as silage either alone or in a mixture and will produce good feed when ensiled either cut or uncut with the ensilage cutter.

APPLES

The ensiling of this crop can be recommended only when there is a surplus of apples, or for drops or culls for which there is no market and where the quantity is in excess of the amount which can be fed immediately. Experiments conducted by the Dominion Experimental Station at Kentville, Nova Scotia, show that apples run through the ensilage cutter, together with a certain amount of hay, make good silage. From 12 to 20 per cent of clover or timothy hay mixed with 80 to 88 per cent of apples gives good results. The silage is palatable and compares favourably with good corn silage. There is a large loss in weight in making apple silage, approximately two-thirds of the tonnage, mostly apple juice being lost in the drainage. Certain other materials could be mixed with apples to good advantage. Possibly green clover or corn could be used and in this mixture about 50 per cent of green corn or clover should be mixed with the apples.

Apple pomace makes excellent silage with very little spoilage. Apple skins and cores make highly palatable silage, but there is an excessive wastage of juice and if the silo is perfectly tight the material is too wet and sloppy for good handling. A mixture of two-thirds pomace and one-third skins and cores makes excellent silage, highly palatable with very little spoilage and of good physical consistency. These may be packed in the silo in layers, two loads of pomace to one load of skins and cores.

If large quantities of apple silage are fed to dairy cows care should be taken to feed it after milking in order to avoid any possible apple flavour in the milk. Apple concentrate may be used as a preservative instead of molasses or acid when ensiling legume crops such as alfalfa or red clover. Some information in regard to apple concentrate appears in this bulletin in the chapter relating to the ensiling of alfalfa.

BARLEY

Barley is supposed to have originated in Asia and was cultivated before any recorded history of man. Barley is widely used as feed for livestock but large quantities are also used in the brewing industry. For human consumption it is prepared for use as breakfast food, pearl barley for thickening soup and barley flour. The cultivation of barley is very similar to that outlined for oats, on page 36 of this bulletin.

If used for silage, barley should be cut in the late milk or early dough stage and ensiled immediately. When barley was cut in the dough stage it contained 37 per cent dry matter and produced good silage. However, when allowed to become more mature and reach the very late dough stage, it contained 61 per cent dry matter and was much too dry. This silage became very mouldy and was absolutely unfit for feed. It did not have enough moisture to permit sufficient packing of the material to exclude the air.

BUCKWHEAT

Buckwheat probably originated in Asia. It has been grown for over 1,000 years in China and has been used in America since 1626. The grain is utilized in the production of flour for griddle cakes. A considerable quantity of middlings from the manufacture of buckwheat flour is used for livestock feed but it is not a popular feed and the crop is not extensively grown.

The chief value of buckwheat lies in its ability to produce a fair crop even under very poor conditions which are entirely unfavourable to other grain crops. It matures quickly and can be seeded at a much later date than is advisable for other grain crops. In a wet spring it is sometimes impossible to seed other grain crops on certain fields sufficiently early to ensure a satisfactory yield but for buckwheat the soil usually dries up soon enough to seed. For grain production buckwheat should be seeded at the rate of $1\frac{1}{4}$ bushels per acre. If intended for silage the rate might be increased to $1\frac{1}{2}$ bushels per acre.

Ensiling Buckwheat

As no information was available in regard to the possibility of ensiling buckwheat, experiments were conducted on the Central Experimental Farm, Ottawa, in order to determine the best methods of ensiling this crop. The work was undertaken in small half-ton experimental silos and was continued throughout a period of five years. The results have shown the proper stage of maturity at which the crop should be cut for silage but no information has been secured on the effect of feeding large quantities of buckwheat silage over a long period.

When buckwheat is ensiled it should be cut in the full-bloom stage and ensiled immediately. Care should be taken to avoid feeding excessive quantities. The buckwheat crop is particularly valuable in smothering weeds.

Buckwheat should be cut for silage when it is in the full-bloom stage and ensiled immediately. It is very important to ensile this crop at the proper stage of development if a good quality of silage is to be obtained. If buckwheat is cut in the bud stage it contains an excessive amount of moisture and the resulting silage is entirely unsuitable for feed. When allowed to reach the full-bloom stage, however, this excess moisture disappears and very palatable silage is produced. It is unwise to decrease the moisture content by allowing the crop to wilt in the field before ensiling owing to the danger of unduly drying portions of the material and thereby causing pockets of mouldy silage.

In one experiment the buckwheat was allowed to grow until it was past full-bloom with many of the seeds formed and some almost ripe. Its moisture content was 78 per cent as compared with 83 per cent for the buckwheat cut in the full-bloom stage. Six tons of this material was placed in a large silo beneath

some corn silage. Although this experiment was not comparable with the small half-ton silos, the palatability of this silage was not as good as that produced from buckwheat cut in the full-bloom stage. The amount of buckwheat silage fed to animals had to be reduced after the first few feeds due to its laxative effects. This objectionable laxative feature was overcome in a similar experiment conducted the following year when excellent silage was made from buckwheat cut in the full-bloom stage. While it is difficult to determine when buckwheat is in the full-bloom stage the main point is to avoid early cutting when the crop is in the bud stage or too late cutting when some seeds have commenced to ripen.

Buckwheat appears to offer some possibilities as a silage crop although it is not recommended where more suitable crops can be grown. Owing to its adaptability to a wide variety of soil and climatic conditions as well as to its smothering effect on weeds, this crop may be used for silage where special circumstances demand. Special care must be taken, however, to properly ensile this crop and to feed it carefully.

CORN

Corn is the most extensively grown silage crop in Canada. It is believed to be of American origin, having been first cultivated in the high plateau region of Central America. The seed of this crop was the chief source of food for the early settlers in North America and to-day occupies the largest acreage of any crop in the United States. Corn grain is extensively used as human food and the many products made from it have a wide variety of uses. Corn meal constitutes a large part of the concentrate ration for cattle and swine, especially in districts where corn is grown for grain.

Soil and Climate for Corn

For best results corn requires a comparatively light, fertile soil, a fair amount of moisture and a reasonably warm temperature. On very heavy clay it is difficult to secure satisfactory yields. The crop is not recommended where the climate is cool and wet. In northern Ontario, in the cooler portions of Quebec and in the Maritime Provinces other crops such as sunflowers, clover or oats and peas will give more satisfactory results than corn. In the Prairie Provinces only the warmer and moister districts are suitable for this crop. For this reason the following information on methods of growing corn applies to Eastern Canada and British Columbia.

ROTATION

In mixed farming districts where corn is grown as a silage crop it is usually seeded after a hay or pasture crop. The crop may be grown in a three-year rotation of corn, oats, clover, in a four-year rotation of corn, oats, clover, timothy or in a five-year rotation of corn, oats, clover, timothy, pasture. It may also be grown after grain in a five-year rotation of oats, corn, barley, clover, timothy. This latter rotation provides an excellent opportunity for thorough cultivation and weed control.

Tillage Practices for Corn

Where corn follows sod, the land should be ploughed in the summer immediately after the hay has been cut. After ploughing, the land should be disked at weekly intervals until the sod has been worked sufficiently to permit the use of a cultivator. The cultivations should then be continued at intervals often enough to keep weed growth under control. Such a procedure is an ideal method of eradicating couch grass and other perennial weeds. It eliminates, moreover, considerable hoeing and cultivation during the year when the corn is growing. Where weeds are not troublesome, however, fall ploughing alone

gives equally satisfactory results as the much more expensive after-harvest cultivation. On light soil spring ploughing gives fairly good results although not quite so good as fall ploughing, while on clay soil fall ploughing is absolutely indispensible. On this type of soil even reploughing in the spring is harmful.

In the spring the soil should be cultivated sufficiently to destroy all weed growth and provide a good seed-bed. The seeding should be done about May 24.

Slightly higher yields are produced when silage corn is seeded in drills rather than in hills. Experiments have been conducted for many years on three Dominion Experimental Farms in various parts of Eastern Canada in order to secure reliable information on the best method of seeding. The following table presents the results of these experiments:—

TABLE 7—COMPARATIVE YIELDS OF CORN GROWN IN HILLS OR DRILLS

Method of sowing	Ottawa, Ont. 18 year average 35″ apart	Cap Rouge, Que. 5 year average 42″ apart	Nappan, N.S. 19 year average 36″ apart
	(tons)	(tons)	(tons)
Hills	20·1	6·2	15·6
Drills	21·0	10·1	16·5

Where couch grass or other perennial weeds are prevalent, the land should be ploughed as early as possible in the summer after the crop has been harvested and thorough after-harvest cultivation practised during the autumn. In the following year much less labour is required to control weeds and the yield of the corn is much heavier. In the above photograph the corn on the right was grown on land treated as outlined above while that on the left was simply spring ploughed. Ploughing once in the late autumn is somewhat superior to spring ploughing but inferior to the after-harvest treatment.

The drill method of seeding gave somewhat larger yields at all three Experimental Farms. Seeding in hills necessitates the use of special machinery but it permits of cultivation in both directions thereby reducing the amount of

hoeing. It is particularly useful, therefore, where weeds are very troublesome. It is preferable under such conditions, however, to control the weeds during the year previous to growing the corn by thorough after-harvest cultivation.

Where drill seeding is practised, a sufficient number of openings or feeds in the grain drill are closed so that the corn may be delivered only through those drills which are the required width apart. For instance, if drill rows 35 inches apart are desired and the grain seeder is built with seven-inch drill spacings, four holes are closed and every fifth left open. To reduce draft and to facilitate straight seeding the intermediate feet are usually removed.

The most suitable distance apart to space the drills or rows of corn is usually from 30 to 35 inches. Narrower spacing, while possibly promoting a greater growth of green material, especially in the more northerly districts, retards the maturity and increases the difficulty of cultivation. Wider spacing reduces the yields especially under conditions where corn does not reach its maximum development.

Manure and Commercial Fertilizers for Corn

As land must be in a fair state of fertility to grow corn successfully it is customary to apply farmyard manure to this crop in the rotation. An application of 12 to 16 tons per acre usually gives best results. If considerable weed seeds are present the manure should be rotted. The method of application will depend largely upon circumstances. If the manure is available it may be ploughed under in the fall. If it is applied in the winter or spring it may be disked in or ploughed under on light soil but on clay land great care should be taken to avoid spring ploughing even where the land had been ploughed the previous summer. Extremely heavy applications of very strawy manure in the spring just before seeding, is very detrimental to the corn crop particularly in a dry year.

Where the supply of manure is limited, a smaller rate of application may be used and the manure supplemented with commercial fertilizers. If no manure is available an application of 450 to 500 pounds of a 3-10-4 or 2-12-6 fertilizer mixture may be used. If a limited supply of manure is available an application of 6 to 8 tons per acre may be used together with one-half the amount of fertilizers previously mentioned. The fertilizer may be applied to the side of the seed in the row if there is a special fertilizer attachment on the corn seeder. Otherwise, the fertilizer should be applied broadcast and disked into the soil.

Seeding Corn

In the warmer portions of Eastern Canada, Wisconsin No. 7 or Golden Glow varieties of corn are very satisfactory. In cooler regions, medium maturing varieties such as Bailey or early Golden Glow may be used to advantage while still earlier varieties include Northwestern Dent, Longfellow and Compton's Early. These latter varieties may be used where the growing season is extremely short. Hybrid corn is also highly recommended in all districts.

The rate of seeding recommended is one-half bushel or 28 pounds per acre when using the drill row method, spaced at thirty-five inches apart. When seeding in hills much less seed is required, 20 pounds per acre being sufficient. Hybrid corn may be seeded at a much lighter rate. Care should be taken to make certain that the percentage germination of the corn is satisfactory, some difficulties being experienced in certain years with poor seed corn. If inferior seed must be used, the rate of seeding should be proportionately increased.

How Crows May Be Prevented From Damaging Seeded Corn

Considerable damage is often done to the corn crop immediately after seeding by crows eating the kernels and thus reducing the stand of the crop. Even after the kernels have germinated these pests will pull corn out of the ground by means of the shoots or first leaves which appear. Many methods have

been tried, as suggested on page 15 of this bulletin, to prevent this damage. One method which has been used considerably is that of treating the seed with tar. If this method is adopted coal tar should be used. Pine tar is too sticky. The tar should be warmed by heating the can of tar in the sun or in a dish of warm water. Warm it until the tar will string like horse hair. Put the seed corn in a large vessel and pour over it some warm water. Drain off the water in a minute or so. Spread over the warm moistened corn 1½ to 2 tablespoonfuls of tar per bushel, and stir immediately and continuously until each kernel comes in contact with the tar and assumes a rather sooty appearance. After treatment, spread the corn on a dry surface to thoroughly dry. If the seed treated in this way passes through the drill or planter with difficulty, a handful of sulphur per bushel of corn will make it run more smoothly.

Where corn grows successfully, it produces a very heavy yield per acre even in seasons unfavourable for other crops. The lowest yield ever secured over a period of twenty-four years on the Central Experimental Farm, Ottawa, has been 12 tons per acre. This provides a good insurance against feed shortage.

While the use of poison to destroy crows is a very effective method and frequently employed by farmers, as mentioned on page 15 of this bulletin, this practice may expose the user to legal action for damages. In the event of causing loss to neighbour's stock, the farmer who has applied the poison may be held responsible.

Cultivation for Corn

While under ideal conditions corn is an extremely productive crop it is very poor to combat weeds. The land must be cultivated sufficiently to destroy weed growth. Before the crop is up the land should be harrowed to kill small

weeds and, if necessary, the harrowing may be repeated when the corn is about three inches high. Cultivation should be started early and repeated as often as necessary to keep the weeds under control, five to eight cultivations during the season being usually required. There is no object, however, in cultivating beyond its effect in destroying weeds; working clean land serves no useful purpose. Such errors, however, are rare. The cultivator should be set fairly deeply at first and then, as the growth advances, adjusted shallower in order to avoid injury to the roots.

The crop should be hoed once or twice during the season depending on conditions. When perennial weeds are present an effort should be made to hoe thoroughly, pulling the roots as much as possible to the surface of the ground where they will be exposed to the air and destroyed. Where corn grows successfully, it is customary to thin the plants to approximately 6 inches apart in the row.

Ensiling Corn

Where the acreage of corn is small and no other method is available, the corn may be cut by hand with a sickle. This is a slow and laborious method, however, as a man will cut approximately only one acre per day. Some corn growers use a sled cutter which consists of a knife or knives mounted on a wheeled frame with a platform. The knife edge travels along the row and cuts the corn while a man stands on the platform, catches the corn and throws it on the ground in bunches.

The corn binder is the implement most generally used to cut corn, the sheaves being loaded on wagons and drawn to the silo. It is then cut by the silage cutter into pieces varying from $\frac{1}{2}$ to 1 inch in length and blown into the silo. Loading arrangements have been introduced which elevate the bundles of corn directly from the corn binder onto the wagon. This eliminates the men required to load the corn bundles from the ground.

The Ronning Ensilage Harvester

A machine known as the Ronning Ensilage Harvester has been operated on the Central Experimental Farm at Ottawa since the fall of 1925. This harvester is designed to handle only row crops, such as corn or sunflowers. It cuts the standing crop in the row and conveys it to a cylinder type cutter where it is reduced to ensilage length. An elevator attached to the harvester carries the cut material into a wagon box drawn alongside the harvester. When drawn to the silo the cut material is simply forked into a pneumatic elevator and blown into the tower silo. When a trench silo is used the cut material may be dumped into the trench.

This system of harvesting corn eliminates the arduous labour of loading bundles, lessens the number of men required from 40 to 50 per cent and permits of economical operation on from 30 to 50 acres of crop. The Ronning Harvester is operated from the power-take-off of a tractor, preferably a three-plough size of tractor. A normal crew would consist of six teams and teamsters, two men unloading at the silo, one or two men as desired tramping the silage in the silo, a three-plough tractor with operator to handle the harvester and a two-plough tractor at the silo to operate the pneumatic elevator or blower. Where a trench silo is used, the blower and two-plough tractor are not required and the men ordinarily employed in tramping the ensilage may be replaced by driving or riding a horse over the cut material in the trench.

With regard to the cost of harvesting and ensiling with the Ronning system as compared with the ordinary binder and ensilage cutter system it may be said that the saving in labour with the Ronning will, under certain conditions, more than compensate for the added cost of equipment and power required. The Ronning Harvester may be expected to harvest and ensile about 7 acres per

The Ronning Ensilage Harvester cuts the standing crop of corn into silage length in the field and loads it into a wagon box drawn alongside of the harvester. The cut corn is then forked into a pneumatic blower and blown into the silo. This system of harvesting corn eliminates the arduous labour of loading bundles and may be economically operated on comparatively large acreages.

10-hour day in corn planted in 35-inch rows and yielding 10 tons per acre. Where the yield is 15 tons per acre the capacity will be approximately 6 acres per day. On a yield of 20 tons per acre the harvester may be expected to handle 5 acres or 100 tons per 10-hour day.

The yield of the silage crop greatly influences the cost of harvesting and ensiling. A low yield increases the cost per ton for both the binder-cutter and Ronning systems of harvesting. Similarly high yields decrease the cost for both systems of ensiling, but the cost per ton decreases more rapidly with the Ronning Harvester system by virtue of the fact that the cost of cutting and ensiling is affected by the yield. With the binder and cutter system only the cost of cutting is affected in this manner, while the cost per ton of loading, hauling and ensiling remains practically constant as the same tonnage is handled per day on all yields.

The cost of the Ronning Harvester was approximately $678. The blower which is required to elevate the corn cost approximately $270. A corn binder cost approximately $190 and an ensilage cutter about $350. The Ronning Harvester eliminates the necessity of six or eight men usually required to load the corn bundles onto wagons. It leaves a somewhat longer stubble which amounts to a loss of about one-quarter of a ton per acre but compared with the corn binder fewer cobs are lost. However, the initial investment is greater and the difficulty and delay in securing repair parts is much greater.

Ensile Corn in the Late Dough Stage

Corn is perhaps the most satisfactory of all crops to ensile as it may be harvested at various stages of maturity with satisfactory results. The best results, however, are obtained when the corn is in the late dough or glazing stage. At this time the yield per acre is considerably larger than when the corn is in the milk stage, the increase in the amount of dry matter being approximately 30 per cent. The amounts of protein and fat are also appreciably increased. While a good quality of silage may be made from corn in the milk stage there is no advantage in cutting at this time if conditions will permit longer development.

It frequently happens that a farmer is obliged to leave corn lying in the field for several days after cutting. To determine the effect of this delay on the quality of the silage, experiments were conducted in which the corn was allowed to lie ten days in the field before ensiling. While the quality of the silage made from this material ranged from fair to good it was not equal to that made from corn ensiled immediately after cutting.

May Corn Be Ensiled Without Tramping?

In filling the silo one or two men are usually assigned to tramp and spread the silage. If the tramping process could be eliminated less labour would be required and the cost of production would be reduced. No absolutely definite information is available, however, as to whether this work may be abandoned with safety. Some farmers report successful results without tramping, as will be observed on page 15 of this bulletin, while others were unsuccessful. In 1930 one small half-ton experimental silo was filled with untramped corn with excellent results. While these few instances do not prove that good silage will always be obtained without tramping they indicate the desirability of further investigation on this matter in order to learn if this part of the silo filling process might be eliminated.

There is no doubt that in a tower type of silo the weight of the silage material itself, once the silo becomes partly filled, will exert more pressure than a man would in tramping and might provide, therefore, sufficient compression of the silage.

There should be a man in the silo to spread the material so that the lighter leafy material may be thoroughly mixed with the coarser, heavier stalks. At the top of the silo, also, where little pressure is exerted by the silage, tramping is very necessary. In a trench silo where there is very little downward pressure, thorough tramping should be practised.

Mixtures of Corn with Leguminous Crops

Corn silage is rather high in carbohydrates and comparatively low in protein. It constitutes, therefore, a slightly unbalanced ration which should be supplemented with other higher protein feeds. Experiments have been conducted in which leguminous crops have been mixed with corn at the time of ensiling in order to increase the amount of protein in the feed and at the same time to improve the quality of the legume silage. Corn has been mixed with alfalfa and soybeans with highly satisfactory results as will be observed in other sections of this bulletin.

The corn binder with loader attachment.

Frozen and Field-Cured Corn

Slight freezing has very little detrimental effect upon the quality of corn silage. Experiments were conducted throughout a period of three years in which a small area of corn was purposely allowed to freeze slightly before ensiling in order to compare the quality of the silage with that made from unfrozen corn. The freezing was severe enough that the tips of the leaves and in some cases the entire leaves apparently suffered a breakdown of the cells and took on a dry wilted appearance. The stalks, however, were probably little affected. The silage made from this slightly frozen corn was of good quality with apparently a slightly higher fibre and carbohydrate content but with a slightly lower acidity, protein, fat and moisture content. The differences, however, were very small.

Where for any reason corn is stooked in the field for two to three months and then ensiled much greater difficulty is experienced in producing satisfactory silage. Experiments were conducted for several years in order to learn if corn could be successfully ensiled under such adverse circumstances, the material being ensiled about January 1, in the small half-ton experimental silos. As the corn was being blown into one silo water was added, while in another silo it was put in dry just as it came from the field. The results were not very satisfactory, however, the quality being only fair to poor, and in one case the entire material was unfit for feed and in no case was it eaten with relish by the cows.

The addition of water improves the quality of the silage made from this very dry and frozen corn but in these small experimental silos such a limited amount of water could be absorbed by the small volume of corn that water added was apparently of little value. The water drained through the material so quickly that it was not absorbed as it might be in a large silo. Eckles of Missouri recommends the addition of about one ton of water for each ton of corn which had been previously cured thoroughly in the field. Hutcheson and Wolfe of Virginia recommend twice as many pounds of water as of stover to be preserved. The ensiling of such dry and frozen corn is not recommended but if it is done sufficient water must be used with the material in order to make the moisture content somewhat similar to that of corn cut in the dough stage.

How Many Years May Corn Silage Be Kept?

Experiments conducted in small half-ton silos on the Central Experimental Farm, Ottawa, have proved that corn silage may be kept at least four years with excellent results. Wherever circumstances require the storing of an extra supply of silage or carrying over a part of the supply for subsequent years it is evident that this practice may be undertaken without fear of failure.

HEMP

Hemp is a plant of Asiatic origin which is grown more particularly for fibre production. The fibre is used in the manufacture of coarse cloth and cordage. The seed is used as food for caged birds. The flowers and leaves yield a narcotic preparation known as bhang or hashish which is sold by pharmacists under the name of *Cannabis indica* and is used in the Orient for its intoxicating effect when chewed or smoked.

Hemp is not grown as a livestock food but due to its comparatively high yields and remarkable smothering effects on weeds it was decided to conduct an experiment in order to learn if it could be used for silage. While the odour of the silage resembled freshly cut material and the appearance seemed fairly good, the fibre content was very high and the cows refused to eat it. Accordingly, it would be unwise to attempt to use the hemp crop for silage.

JERUSALEM ARTICHOKE

Jersualem artichoke is sometimes referred to as the American sunflower. The above-ground portion of the plant resembles the common sunflower although much finer in growth, having smaller stems, leaves and flowers. It is a perennial plant, moreover, while the sunflower is an annual.

The Jerusalem artichoke is a rather unusual plant producing a considerable amount of edible growth both above and below ground. The underground portion grows in the form of small white tubers which resemble potatoes in composition. These tubers are sometimes used for human food as well as for livestock, especially hogs, which may be allowed to root them out of the ground. Tubers left in the soil will grow and produce a crop the following year. For this reason they are difficult to eradicate once they have become established and they may become a nuisance.

The tubers are planted in hills three feet apart each way. One tuber to each hill is used and about 400 pounds of medium sized tubers are required to seed an acre. Following planting, the crop is handled much the same as sunflowers. It may be cultivated at frequent intervals until the plants are about two feet high. It is somewhat more resistant to frost than sunflowers and considerably more resistant than corn.

This crop may be cut for silage when the plants are just commencing to bloom. The quality of the silage is somewhat similar to that produced from sunflowers. While artichokes have been enthusiastically promoted from time to time in certain districts they have never become generally popular.

KALE

Kale is a member of the mustard family. It resembles the rape plant although somewhat larger. Like rape it is a fast-growing crop which may be utilized as a catch crop when other crops fail. It is not grown at all extensively although formerly it was used considerably for human consumption in soups and salads. When fed to livestock it is usually pasteured in a manner similar to rape. It should be sown in drills about 20 inches apart at the rate of 4 pounds per acre. Cultivating the crop to keep weeds under control is essential.

Good silage has been obtained from kale throughout a period of five years during which the experiments with this crop were conducted. The crop was ensiled in small half-ton experimental silos immediately after cutting and drawing from the field. The material was cut through the cutting box and tramped into the silo. The silage had a slightly acid or fermentation odour and was quite palatable to cows. Kale contains a very high percentage of moisture averaging 85·8 per cent.

In order to conserve this excessive moisture ten per cent of straw was added in certain experiments at the time of ensiling. The quality of the silage from this mixture, however, as an average of four years' experiments, was not as good as that from kale alone. The moisture content of the mixture was reduced 5 per cent but the palatability was impaired and in one instance the cattle ate the kale but left the straw.

When other silage crops are not available and a fast-growing crop is desired kale may be used. It is not recommended, however, as a general silage crop.

MANGELS

Mangel tops provide a considerable amount of feed. Where a crop yielded 31·2 tons of roots per acre, the tops weighed 5·0 tons. The percentage of dry matter in the tops was somewhat higher than that in the roots and therefore the total dry matter was 3·3 tons per acre of roots and ·67 of a ton of tops.

While the tops are usually consumed in the field or drawn away and fed in desired amounts, they are occasionally ensiled. If this is done certain precautions should be observed if successful results are to be obtained. The most important point is to allow the tops to wilt somewhat before placing in the silo. Mangel tops contain too much moisture to allow for ensiling directly, making it necessary to wilt them for about a week before ensiling. If ensiled immediately after pulling, mangel tops make very undesirable silage which is unpalatable and worthless. Care should be taken to eliminate as much earth as possible by shaking the tops and piling in heaps as soon as removed from the roots. It is not necessary to cut the mangel tops with the silage cutter but the material should be well tramped in the silo. Humphrey of Wisconsin recommends mixing an equal weight of corn with beet tops for silage.

Mangel roots were pulped and tramped into a small experimental silo. Although the odour of the silage seemed fairly satisfactory, the cattle refused to eat it. As the storing of roots can be done more economically in a root cellar than in a silo, there is no object in ensiling mangel roots.

MILLET

Millet is the name used to designate a considerable variety of plants, such as foxtail millet, Japanese or barnyard millet, proso millet, pearly millet and others. The cultivation of this crop is older than the history of man. Hutcheson and Wolfe in their "Production of Field Crops" refer to millets being used by the lake dwellers of Switzerland in the stone age and by the Chinese in religious ceremonies, as early as 2700 B.C. The crop was introduced to the North American continent about 1849.

Up to comparatively recent times millets constituted a very important source of cereal food for mankind. Although they have been replaced in recent years to quite a considerable extent by other cereals, they are still used quite extensively in India, China and North Africa. In North America millets are grown almost exclusively as forage crops. Due to their rapid growth they are employed quite extensively as a catch crop where other crops have failed.

Good silage may be made from millet when ensiled as soon as the crop is fully headed. This photograph shows Proso or hog millet which is a suitable variety for silage.

Millets require fairly warm weather to produce maximum growth. Accordingly, too early seeding in the spring must be avoided. The seed should be sown about one inch deep at the rate of 25 to 30 pounds per acre. In from 70 to 80 days a crop of hay or silage will be produced. Yields of 9 tons of green material and 3·5 tons of field-cured hay are common in areas adapted to this crop.

Although primarily employed for other purposes, millet may be used successfully as silage. It has been ensiled at Ottawa in the small half-ton experimental silos as soon as the crop was fully headed. Good silage has resulted, the animals eating it with apparent relish. In the absence of corn or other silage crops, millets will make very satisfactory silage.

OATS AND MIXTURES OF OATS, PEAS AND VETCHES

Very little is known in regard to the origin of oats. They were reported at the beginning of the Christian era and are believed to have been grown first in the eastern portions of Europe or Western Asia. Peas are a native of Italy and have been grown in the East from time immemorial; they are, in fact, considered to be one of the oldest of cultivated crops. Vetches are native to the Mediterranean region.

In cool regions where corn is not adapted, a mixture of oats and peas makes satisfactory silage. Where the conditions of the crop permit, the grain binder should be used for cutting. The crop should be ensiled when the oats are in the early dough stage.

In the cooler regions of Canada it is probable that oats, or mixtures of oats and peas, or of oats, peas and vetches, the latter being sometimes called the O.P.V. mixture, will give better results for silage than will either corn or sunflowers. Oats alone are often used but the quality of the feed is not equal to that obtained from the mixtures. However, in the Prairie Provinces oats are grown very extensively as green feed in place of "tame" hay and are often used as silage. Under suitable conditions yields as high as 10 tons of green material per acre may be expected.

Rotational Fertilizer and Cultural Practices for Oats or Oats and Peas

Oats, mixtures of oats and peas, or of oats, peas and vetches may be grown successfully after any crop in the rotation. They will follow sod or grain or may be utilized as a catch crop or annual hay in the event of a failure of the hay crop. While the mixtures may be used as a nurse crop for seeding grass and clover mixtures, it is preferable to seed down with a single grain crop, such as wheat, barley or oats.

Neither oats nor the mixtures of oats, peas and vetches require as much manure or fertilizers as do corn or sunflowers. Unless the soil is extremely poor, an application of 10 tons of farm manure is sufficient. If excessive dressings of manure are used there is a tendency for the crop to lodge, making harvesting difficult and impairing the quality of the silage, as the leaves and stems of the lodged grain become soiled with earth and moulds develop. If no manure is available an application of 300 pounds per acre of a 2-12-6 commercial fertilizer may be used with advantage. As a supplement to a small dressing of manure superphosphate alone at 200 pounds per acre may prove beneficial.

Fall ploughing is much superior to ploughing in the spring. This is especially true on clay soil but applies also on lighter soils. Where the crop is to be sown on sod land if it is weedy, ploughing in the late summer or early fall as soon as the previous crop has been removed and cultivating throughout the fall is very advisable. The cultivations should be at sufficiently frequent intervals, possibly every week or ten days, to keep down weed growth. Where these crops follow an intertilled crop, it is not necessary to plough the land. In fact where annual weeds are present it is preferable to disk or cultivate rather than to plough in order to avoid bringing viable weed seeds to the surface of the ground. In regions where the corn borer is present, however, ploughing corn stubble is required as a means of control. In the spring the land should be disked or cultivated as early as soil conditions will allow and the crop seeded at a depth of about two inches.

Oats should be seeded at the rate of $2\frac{1}{2}$ bushels per acre. Where oats and peas are used, the mixture should consist of 2 bushels of oats and 1 bushel of peas per acre. In districts where vetches grow well the peas might be reduced to $\frac{3}{4}$ of a bushel and $\frac{1}{4}$ bushel of vetch seed added. Either of the mixtures should be seeded at the rate of 3 bushels per acre. The varieties recommended are Banner or Victory oats, Arthur, MacKay or Chancellor peas and common vetch.

Harvesting and Ensiling Oats or Oats and Peas

Where the condition of the crop will permit, the grain binder may be used for cutting. A considerable saving of labour results from the use of this machine as the sheaves can be handled much more easily and quickly than loose bundles. In some instances, however, the crop becomes so badly lodged as to make cutting with the binder impossible and it becomes necessary to use the mowing machine. In this event the cut material must be bunched in the field by hand, involving considerable extra labour. With both methods the material is hauled to the silo, where it is cut and blown into the silo with an ensilage cutter.

It is advisable to cut oats or oats, peas and vetches for silage when the oats are in the early dough stage. Experiments have been conducted in which the oat crop has been cut both when in the milk stage and in the dough stage with satisfactory results, but as the quality of the silage was slightly superior from the dough stage material and as the yield per acre was somewhat greater, this stage of maturity is recommended. In one experiment on acount of continued wet weather, it was impossible to cut the crop when the oats were in the dough stage, the cutting being delayed until they were almost ripe. This resulted in very dry material which produced mouldy silage of very inferior quality. Care should be taken to avoid wilting this crop excessively between the time of cutting and ensiling. No advantage is derived from this practice and sometimes injurious results are produced, especially if the crop is advanced in maturity. Certainly the crop should not be allowed to lie in the field after cutting for more than two or three hours before ensiling. Experiments have been conducted in which the crop has been allowed to wilt 5 hours in the field after cutting. While this was not injurious to the crop cut when the oats were in the milk stage, when the practice was followed with the oats in the

dough stage it produced very mouldy silage, totally unfit for feed. Evidently the wilting of this material caused it to become too dry, resulting in the development of moulds.

The addition of water to oats, peas and vetches at the time of ensiling does not improve the quality and sometimes causes the production of very poor silage. Experiments conducted when the oats were cut in the milk stage with additions of 15, 20 and 30 per cent of water produced very poor silage, especially with the larger amounts of water. When 15 per cent of water was added, a fair quality of silage was obtained but no better than that from material to which no water was added. Even when the oats were in the dough stage, the addition of water did not produce satisfactory silage. A brief period in the growth of the oat crop makes a considerable difference in the maturity and in the amount of moisture which it contains. Experiments conducted on the Central Experimental Farm at Ottawa have shown that the moisture content of the material plays a very important role in the success or failure of ensiling oats. In some experiments where the moisture content was 62 per cent it was found to be too low to make satisfactory silage, while in other experiments, where it reached 87 per cent, it was too high. Apparently 75 per cent is the most suitable moisture content for ensiling oats. The oats should be cut into $\frac{1}{2}$ to 1 inch lengths with the silage cutter and blown into the silo. Uniform distribution throughout the silo and thorough tramping are recommended.

Where oats, peas and vetches were put into small experimental half-ton silos without being cut by an ensilage cutter, mouldy silage totally unfit for feed, was produced. Good silage was produced in these silos where the material was cut to three-quarter inch lengths. The quality of the silage stored for 3, 7 and 9 month periods in the silo was uniformly excellent, indicating that these lengths of storage had no effect upon the equality.

POTATOES

Potatoes are produced quite extensively in every province in Canada. The crop is usually produced for human consumption but small-sized and low-grade potatoes are often utilized for livestock feed. In fact, when the market price is low, even the high-grade product may be used for this purpose. Potatoes contain approximately twice the percentage of dry matter that is found in turnips or mangels and more than double the amount of total digestible nutrients. When used for livestock they are more suitable for pig feed but may also be used to a limited extent for cattle, sheep and horses. They may be fed only in limited quantities to dairy cows because of the possibility of producing milk of poor flavour and reducing the quality of butter. Neither potato sprouts, unripe potatoes, nor the water in which potatoes have been boiled should be fed to stock because of the presence of solanin, which is a poisonous substance injurious to both humans and farm animals.

Potatoes have never been used to any considerable extent as silage. In experiments conducted at the Central Experimental Farm, Ottawa, potatoes ensiled alone were absolutely worthless. A considerable amount of moisture drained away from the silo soon after filling and only a very small amount of the original mass remained when the silo was opened five months after ensiling. The potatoes had shrivelled slightly and appeared somewhat corky in texture. The silage had a slightly putrid odour and was refused by the cattle.

When one part by weight of potatoes was mixed with one part of green alfalfa the resulting silage was excellent. The odour was agreeable with a slight indication of fermentation. The cattle ate the silage with relish. The same was true of a similar mixture of potatoes and freshly cut red clover. When potatoes were mixed with straw even in the proportion of one part of straw by volume to one part of potatoes, the silage was very dry. The odour was

agreeable, however, and the palatability good. Potatoes, one part by volume mixed with one part of field-cured red clover and timothy hay, made slightly better silage than when mixed with straw but not so good as when the fresh alfalfa or clover was used in the mixture. When one part by weight of green corn was mixed with one part of potatoes, the silage was very good.

Some investigators have reported good results from mixing 2 per cent by weight of corn meal with pulped raw potatoes. However, experiments conducted with this mixture on the Dominion Experimental Farm at Fredericton, New Brunswick, did not produce very satisfactory silage. Although pigs weighing over 100 pounds would eat the mixture, they did not produce very good gains. There is a considerable loss of dry matter by fermentation when raw potatoes are ensiled. In an experiment where 60 barrels of potatoes, containing 2,363 pounds of dry matter and 495 pounds of moist corn meal were ensiled in a trench silo, only 1,345 pounds of silage were removed, giving a loss of 43 per cent.

Cooked potato silage gave very good results at Fredericton, New Brunswick. Forty barrels of potatoes were cooked with a small pressure boiler, four barrels at a time, and packed in a trench silo measuring 8 feet long, $2\frac{1}{2}$ feet deep and 4 feet wide at the bottom. The potatoes were covered with straw and earth, care being taken to pack the earth tightly around the edges, especially as the silage settled, to exclude the air. No preservative whatever was mixed with the potatoes and the silage kept in excellent condition with comparatively little loss. This silage was very palatable and was relished by pigs of all ages. In hog feeding experiments cooked potato silage, when fed with grain and either skim milk or fish meal, had a barley equivalent of 30·71. That is, 100 pounds of raw potatoes, containing 24·71 pounds of dry matter, in the form of cooked potato silage, was equal to 30·71 pounds of ground barley. However, special equipment, not available on most farms, is necessary to make cooked potato silage.

These experiments with potato silage show what methods will give good results. While the use of potatoes as silage is not recommended as a general practice, when there is a surplus of this crop it is possible, by using the proper methods, to utilize it as livestock feed.

PRICKLY COMFREY

Prickly comfrey is a little known forage plant although it is occasionally exploited in some districts. The species commonly cultivated for forage is the gigantic prickly comfrey.

Only one experiment was made with this crop, the silage being an absolute failure. The moisture content of the crop at the time of ensiling was 92 per cent. The material rotted in the silo, had a very disagreeable putrid odour and was entirely unfit for feed. While one experiment is not sufficient on which to base a definite conclusion there seems little reason to believe that prickly comfrey will become a popular silage crop.

RED CLOVER

Red clover is a native of Europe probably brought to the United States sometime previous to 1747. It is the most extensively grown legume crop in the humid regions of Canada. It is usually a biennial plant although sometimes it persists for three years or more. Red clover is commonly grown in a mixture with timothy and is extensively used as a forage feed for livestock. Being a legume crop it has the faculty of storing the nitrogen obtained from the atmosphere in the nodules on its roots and is useful, therefore, in improving the fertility of the soil. Red clover is used extensively as a silage crop in some parts of Canada.

Red clover is best adapted to regions with abundant rainfall. It is not grown to any appreciable extent in the Prairie Provinces of Canada. Red clover is fairly resistant to cold provided resistant strains are used. It will grow on a wide variety of soils but does best on a fairly heavy, well-drained, fertile soil, high in lime. Red clover may be seeded with a nurse crop of wheat, oats or barley at the rate of 10 pounds per acre or as is more commonly practised in a mixture of 8 pounds of red clover, 2 pounds of alsike and 10 pounds of timothy.

Harvesting and Ensiling Red Clover

Excellent silage may be made from red clover. The best quality is obtained when the crop is cut in the full-bloom stage and ensiled immediately. However, the conditions required for ensiling red clover are not as exacting as are those for alfalfa or buckwheat where certain definite methods must be followed if successful results are to be obtained.

Red clover makes very satisfactory silage when cut in the full-bloom stage. Alsike is a very similar crop, but will grow on more acid and wet soils, and makes excellent silage when cut in the full-bloom stage.

While it is probably preferable to ensile red clover immediately after cutting, it may be allowed to wilt in the swath for five or six hours without any appreciable injury. Under certain conditions it may be left for longer periods but this involves the risk of excessive drying. An experiment has been conducted in which red clover remained in the swath two days before ensiling; during this period a thunderstorm occurred giving three-quarters of an inch of rain. In one silo 50 per cent by weight of water was added while in another 50 per cent of freshly cut clover was added to the wilted crop. In both cases the silage was of good quality.

Excessive wilting before ensiling has resulted in absolute failure. Where red clover was allowed to remain six days in the field before ensiling the silage was unfit for feed. This experiment was undertaken in order to simulate a condition in which an attempt is made to cure red clover for hay but, on account of wet weather after cutting, it is impossible to cure the hay properly. If such material could be ensiled satisfactorily considerable loss would be avoided. Unfortunately, the results from this experiment, even where water was added, were very unsatisfactory.

Experiments have been conducted in an effort to ensile red clover without cutting with the ensilage cutter. This involves greater risk of producing an inferior quality of silage. However, if this practice is followed it is essential to cut the crop in the full-bloom stage and ensile it immediately, being careful to thoroughly tramp the material in the silo. If the crop is allowed to develop beyond the full-bloom stage or is permitted to wilt excessively in the field poor silage will be produced.

Like other legumes, red clover may require special treatment with carbohydrates or acids. The treatments outlined for alfalfa on page 20 may be used on all legume or high protein crops.

SOYBEANS

The soybean is a native of Eastern Asia and is believed to have been introduced to North America about 1800. It is grown very extensively in China and Japan where it is used for human food. In Canada it is grown mainly in the central and southwestern portions of Ontario but its use is extending with the development of improved varieties to other parts of Canada. Its seed is used for livestock feed. The seed contains about 17 per cent of oil which is extracted and used in the manufacture of soaps, paints and a variety of food products. The green plant may be used for hay, pasture or silage. Soybeans for silage are planted with a grain drill in rows 30 inches apart with the plants about three inches apart in the row. This requires about 30 pounds of seed per acre.

Soybeans should be ensiled when the pods are well filled but before the leaves begin to turn yellow. They may be ensiled either alone or, as is more frequently the case, in a mixture with corn. They may be mixed in any proportion but as corn is an almost ideal silage crop, it might be used in relatively large amounts. A mixture of three parts of corn to one part soybeans produces an excellent quality of silage.

SUNFLOWERS

The sunflower is generally recognized as indigenous to North America. It was used as food by the American Indians, the seeds being eaten raw or pounded and mixed with other seeds into flat cakes which were dried in the sun. Champlain, in 1615, found the Indians in the vicinity of Georgian Bay, cultivating the sunflower. The oil which they obtained from the seeds was used on their hair.

The sunflower under cultivation has been widely used as an ornamental plant, and its seeds are valued as feed for birds and poultry. The seeds are also used for human food and as a concentrate feed for cattle. It is only in comparatively recent years that the crop has been used for silage. When grown for seed, yields of 30 to 60 bushels of seed per acre are not unusual and as a silage crop a yield of 15 to 25 tons per acre may be obtained.

The silage produced from sunflowers is not as palatable as that from corn. Cattle soon become accustomed to it, however, and the production of meat or milk is usually well maintained. The two crops have approximately the same feeding value, but sunflowers have a tendency to stimulate the kidneys.

Soil and Climate

Sunflowers will grow successfully under a wide range of conditions but are adapted to cool and humid regions. They will grow satisfactorily under conditions of temperature and moisture which practically prohibit the growing of corn. Sunflowers produce higher yields, also, on heavy clay soil than can be obtained from corn. Where corn can be grown successfully, however, it is preferable to sunflowers.

Cultural, Rotational and Fertilizer Practices for Sunflowers

The best methods of growing sunflowers are in general the same as those used in growing corn which are described in detail in a previous section of this bulletin. A grain drill may be used to seed the crop by closing a sufficient number of openings or feed runs in the drill box so that the rows may be spaced from 30 to 35 inches apart.

The rate of seeding should be approximately 10 pounds per acre. The Giant Russian variety of sunflower is most generally grown. Seeding may be done somewhat earlier than corn, experiments indicating that best results are obtained from the middle to the end of May. Like corn, the land may be harrowed before the sunflowers are up and again when they are about three inches high in order to kill annual weeds. Cultivating and hoeing should be done at intervals throughout the season in order to control weed growth. This is especially necessary in the early part of the season. Later in the season the sunflowers, which are an excellent smother crop, tend to keep the weeds in check. If the early cultivation is thoroughly done the land may remain comparatively free from weeds.

Sunflowers are more adapted to a cooler climate than corn and grow better on a heavy clay soil. They should be ensiled when from 50 to 60 per cent in bloom.

Where sunflowers grow very rank, higher yields have been obtained by thinning the plants to six inches apart in the rows. On heavy clay land, or where the crop does not attain its maximum growth, higher yields may be obtained from unthinned sunflowers. The following table shows the results of experiments conducted at Ottawa and Kapuskasing, Ontario.

TABLE 8—EFFECT OF DISTANCE OF THINNING ON THE YIELD OF SUNFLOWERS

Treatment	Ottawa, Ont.		Kapuskasing, Ont.
	Sandy soil (5 years)	Clay soil (9 years)	Clay soil (6 years)
	tons	tons	tons
Plants thinned to 10″ apart in row	16·50	–	–
" " " 6″ " " "	17·27	–	–
" " " 3″ " " "	17·31	12·92	10·91
Plants not thinned	16·88	15·62	12·03

Ensiling Sunflowers

It is generally advisable to cut sunflowers when they are from 50 to 60 per cent in bloom. At this stage there is a larger percentage of dry matter than at earlier stages and they are more easily handled than when more mature. If the heads are allowed to develop until the seeds are in the dough stage, the stalks become "top heavy" and difficult to cut and handle in the field. Difficulty is experienced also in forcing the large heads through the throat of the ensilage cutter.

Experiments have been conducted in which sunflowers have been successfully ensiled in the bud stage, 50 per cent bloom stage, and full-bloom stage. Where the crop is very immature it is sometimes advisable to allow it to wilt one day in the field after cutting before ensiling. No difficulty is experienced in making satisfactory silage from sunflowers but the best results may be expected when the crop is cut in the 50 to 60 per cent bloom stage.

SWEET CLOVER

White sweet clover and yellow sweet clover are the two species most generally grown although some twenty different species are known. The history of this crop goes back at least two thousand years. It is native to Europe, Africa and Asia and was introduced from Europe to North America in 1738. At first it received very little attention, being regarded as a weed, but, of late, it has occupied a place of considerable importance as a field crop.

Being a legume, it has the property of utilizing the free nitrogen of the air and storing it in the plant tissues thus adding a very important and rather expensive element to the soil. Sweet clover makes an excellent pasture crop. Unlike other clovers and alfalfa, it seldom causes bloat. Although stock do not take to it readily at first, probably on account of its characteristic bitter taste, they usually become accustomed to it in the course of a few days.

Cut at the proper stage just when the plants are in the bud stage, before the stems become too coarse and woody, a fair quality of hay may be produced. It is difficult to cure, however, and is not as popular for a hay crop, as is either alfalfa or red clover.

The crop has long been recognized by beekeepers as a valuable honey crop. When grown for seed, sweet clover will produce from three to five bushels per acre. As a silage crop, sweet clover is very satisfactory.

The yield of sweet clover has not been particularly high on the Experimental Farm at Ottawa, two tons of hay per acre being an average yield as compared with two and one-half tons for red clover and three and one-half tons for alfalfa. Two to three tons of sweet clover hay per acre may be considered a fairly good yield.

Rotational, Fertilizer and Cultural Practices for Sweet Clover

Sweet clover follows a grain crop in the rotation. It is usually seeded with a nurse crop of wheat, barley or oats and will provide, in favourable seasons, some pasture after the grain has been cut. Care must be taken, however, to avoid grazing too closely. The year following the seeding the crop may be used for hay, pasture, seed or silage.

It is practically impossible to grow sweet clover on acid soils. In fact this crop is more sensitive to acidity or sour soil conditions than is alfalfa. If the soil is acid, an application of one to two tons of ground limestone is usually required to correct this condition. Although sweet clover will grow on soils relatively low in fertility, a high yield is usually assured only where the soil is in a reasonably good state of fertility. Under most conditions, the fertilizer or manure applied to the corn or to the grain crop preceding the sweet clover is sufficient for the needs of the sweet clover. If the fertility is very low, a top dressing of 8 tons of manure per acre or 300 pounds of 2-12-6 commercial fertilizer mixture may prove beneficial.

Inasmuch as sweet clover is usually seeded with grain as a nurse crop, the cultural treatments are necessarily the same as for oats or mixtures of oats, peas and vetches described on page 36 of this bulletin. Leguminous crops usually contain some hard-coated seeds which are impervious to moisture and, therefore, slow to germinate. Hard seeds have been known to remain dormant in the soil for several years. They constitute one of nature's methods of continuing the species under adverse conditions. The scarifying or scratching of the surface of these hard seeds increases their permeability to moisture and their power to germinate. Scarifying has become, therefore, a common practice which assists materially in increasing the stand and reducing the cost.

Scarified seed is usually planted at the rate of 12 to 15 pounds per acre while unscarified is seeded somewhat heavier at from 18 to 20 pounds per acre. The variety ordinarily used is the white blossom sweet clover. If sweet clover is being grown for the first time the seed should be inoculated with legume bacteria. This inoculation enables the sweet clover to develop nodules on the roots and thereby to make use of the free nitrogen of the air. Information in regard to this inoculation may be obtained from the Division of Bacteriology and Dairy Research, Central Experimental Farm, Ottawa.

Harvesting and Ensiling Sweet Clover

Sweet clover may be cut either with a binder or a mowing machine. In either case it is advisable to leave a fairly long stubble of about 6 to 8 inches at the time of the first cutting in order to promote the growth of the aftermath. With the mower this may be done by using a specially made shoe attachment which raises the cutter bar to the desired height.

While the mowing machine may be used for cutting sweet clover, the binder method is more generally recommended. In cutting for hay there is great danger of losing the leaves which form the most nutritive part of the plant and which dry out and fall off before the somewhat coarse, succulent stems become sufficiently dry to harvest. Cutting with the binder overcomes this difficulty to some extent. When used for hay the sheaves should be bound small and loose to permit more rapid drying and to lessen the danger of mould development. The crop should then be stooked with about four sheaves to the stook and hauled to the barn when dry. For ensiling, larger and more tightly bound sheaves may be made in order to facilitate handling.

The most suitable stage to cut sweet clover for silage is when about one-half of the plants have begun to show their first blossom. Experiments have been conducted in which the crop has been ensiled at four different stages of maturity: in the bud stage, one-half bloom, full-bloom and one week after full-bloom. Excellent silage was produced from the first three stages of development but

when the crop was cut one week after full-bloom it was too mature to produce a satisfactory quality of silage. When cut in this later stage only once in four trials has good silage been obtained while in one case the quality was so poor and the odour so disagreeable that it was unfit for feed. While cutting in the full-bloom stage permits a slightly higher yield per acre than in the one-half bloom stage the quality is perhaps not quite so good and there is not as much opportunity afforded for the growth of a second cut of sweet clover. At Ottawa, however, it has rarely been possible to secure a satisfactory second cut no matter at what stage the first cut was taken.

Sweet clover may be used as silage more successfully than as hay. It should be cut for ensilage with the binder when about one-half of the plants have begun to show their first blossom.

It is advisable to ensile sweet clover immediately after cutting or at least within two or three hours afterwards. Experiments have been conducted in which the crop has been cut both in the bud and full-bloom stages and allowed to lie in the sun for five hours after cutting before drawing to the silo. In some instances wilting has improved the quality of the silage, especially when the crop was cut in the bud stage, but, in other cases, pockets of mould have developed which demonstrates the danger from this practice particularly if the material is overwilted.

The addition of water to sweet clover for silage is not to be recommended. Water has been added to crops cut in the bud stage as well as when cut one week after full-bloom but in no case was there any improvement in the quality of the silage and in most instances the silage was inferior to that where no water was added.

Where sweet clover was not cut with the ensilage cutter, being placed direct into the half ton experimental silos, the silage was very inferior in quality and practically unfit for feed. The quality of properly made sweet clover silage, stored for 3, 6, and 9 months in the silo, was uniformly good indicating that these lengths of storage had no effect whatever upon the quality.

Mouldy Sweet Clover Silage Unsafe to Feed

Feeding mouldy silage made from any crop is not a good practice, but the use of mouldy sweet clover silage may be decidedly dangerous. Well-made sweet clover silage is excellent feed, and while not all mouldy silage produces fatal results, mouldy sweet clover silage is sometimes injurious to livestock. A poisonous substance supposed to be found in certain types of mouldy silage has the power of destroying either the blood platelets or the cells from which they arise and also of weakening the blood vessel walls so that they are easily ruptured. Animals fed mouldy silage have died from internal haemorrhages or from bleeding to death following simple operations. While the type of mould which produces the disease has not been definitely isolated, it is well to practise extreme caution in feeding sweet clover silage when any mould is noticed. The mouldy silage should be discarded.

TIMOTHY

Timothy is a native of Europe although it was first grown as a cultivated crop in the United States. It is the most important grass used for hay in the humid regions of North America. The crop is used very extensively as a hay ration for horses and is also considered a satisfactory feed for cattle. It is usually grown in a mixture with clovers at the rate of 8 pounds of red clover, 2 pounds of alsike and 10 pounds of timothy per acre, and the timothy being a perennial plant continues to grow for many years after the clovers have disappeared.

Although not considered as an ideal crop for silage, experiments were conducted in order to determine if it could be used as silage in the event of a scarcity of other crops or where the yield of timothy was in excess of that required for hay. Unlike alfalfa and buckwheat which are most likely to give trouble in ensiling when the material is too green having too high a moisture content, timothy is liable to be too dry.

If used for silage, timothy should be cut just before it comes into bloom and ensiled immediately without any wilting in the field. Sometimes it may be ensiled successfully in the full-bloom stage but if the crop should happen to be exceptionally dry, the silage will be a failure. Where the moisture content of the timothy was as low as 47 to 57 per cent the silage was mouldy and unfit for feed while when the content reached 65 per cent a very good quality of silage was obtained.

TURNIPS

If turnip tops are to be ensiled successfully the same precautions should be followed as have been outlined for the mangel crop. Turnip roots did not make satisfactory silage.

WEEDS AND CROP REFUSE

Circumstances arise occasionally when it is desired to have reliable information on the utilization of various weeds and crop refuse as silage. Westover of the United States Department of Agriculture has reported in the Journal of the American Society of Agronomy, Vol. 26, No. 2, February, 1934, page 106, the results of experiments conducted on the palatability of silage made from a large number of weeds and crop refuse as well as from many cultivated crops. The crops were ensiled in barrels for a period of at least three months when they were fed to cattle to determine their palatability.

Westover grouped the relative palatability of the silage on the basis of (1) eaten with avidity, (2) eaten readily, (3) eaten reluctantly, (4) eaten only partially, and (5) refused entirely. The following table shows the palatability

of some of the weeds and crop refuse grouping 1 and 2 as good silage and 3 to 5 as poor silage with the number opposite each plant referring to the individual numbers listed above which indicate the more specific classification to which reference was made in the original article.

TABLE 9—PALATABILITY OF SILAGE FROM WEEDS AND CROP REFUSE

Good silage		Poor silage	
Canada thistle	2	Cocklebur	3
Golden rod	2	Coffee weed (*Sesbania floridanum*)	3
Milkweed (*Asclepias Syriaca*)	2	Cypress weed (*Eupatorium capillifolium*)	4
Prickly lettuce (*Lactuca sp.*)	2	Gum weed (*Grindelia sp.*)	5
Red root pigweed (*Amaranthus retroflexus*)	1	Mustard (*Brassica nigra*)	4
Sour dock (*Rumex acetosa*)	2	Nettle (*Urtica gracilis*)	3
Wild sage (*Artemesia sp.*)	2	Poke berry (*Phytolocca decandea*)	4
Wild sunflower	2	Potato tops	5
Lamb's quarters (*Chenopodium album*)	2	Russian thistle	4
		Smart weed (*Polygonum Hydropipe*)	5
		St. John's-wort (*Hypericum sp.*)	3
		Squash vines	4
		Tarweed (*Madia sp.*)	3
		Tomato tops	5
		Wild gourd (*Micrampelis oregana*)	3
		Wild hemp (*Sesbania sp.*)	3
		Onion tops	3

These experiments have shown that while certain weeds make very palatable silage other weeds have failed to produce good silage. It is possible, nevertheless, that by varying the method of ensiling some of these crops might be ensiled satisfactorily, especially those which were eaten reluctantly and were difficult to classify into good or poor silage. While Russian thistle cut when nearly mature was reported in these experiments to produce poor silage, Dvorachek in Colorado reports that where the crop was ensiled when quite young before it became woody, it produced good silage. Westover found that mixing alfalfa with Russian thistles improved the quality. As hay, Russian thistles have been used quite extensively during dry years by farmers in the Prairie Provinces; the crop should be cut before it becomes prickly and stacked with about one day's curing. As silage it has been used to some extent.

SPECIAL SILAGE PROBLEMS

Mouldy silage is one of the most common troubles experienced in ensiling crops. The most frequent cause of mouldy silage, perhaps, is the failure to provide an airtight silo. It is essential that the silo have no holes or cracks in the walls through which air may gain access. Other causes of this trouble may be attributed to the following conditions. The crop may have been ensiled when too far advanced in maturity and hence may not contain a sufficient amount of moisture to ferment properly. Too dry silage may be made, also, by leaving the crop in the field too long after cutting. Preferably the crop should be ensiled the same day it is cut. Attempts to ensile partly cured hay usually result in failure. If the crop is severely frozen it may become too dry and develop mould unless water is added at the time of ensiling.

Mouldy silage may be caused, also, by insufficient tramping in the silo which allows too much air to remain in the silage. Although some have contended that the weight of the silage, itself, is sufficient to settle it, and it is true its weight is many times greater than that of a man tramping in the silo, nevertheless tramping compacts the silage immediately and especially near the walls where otherwise it might not settle satisfactorily. Some believe that the silage should be tramped a little each day after the silo has been filled until it stops

settling. Great care should always be taken when tramping silage to make certain there is adequate circulation of air or the concentration of carbon dioxide gas caused by the fermentation of the silage may be sufficient to suffocate and cause the death of any one getting into the silo at this time.

Hybrid corn, on account of its stiffer stalk which may remain green after the grain has become ripe, should be watched carefully so that it is cut in the proper stage of maturity as indicated when the kernel is in the glazing stage. Otherwise, in southern districts, if the crop gets too mature, the stalks become very stiff and may not pack well. If danger is feared from mouldy silage the crop should be cut reasonably fine by the ensilage cutter, corn being cut into pieces of from $\frac{1}{2}$ to $\frac{3}{4}$ inches in length, and legumes even shorter. The knives of the cutter should be sharpened regularly, otherwise the crop will not be cut properly.

While mould may develop if the crop is put in the silo too dry, on the other hand if ensiled with too much moisture corn may produce a very acid silage and legume crops a decomposed or rotten silage. The remedy is to ensile the crop at the proper stage of maturity under suitable conditions. Corn rarely gives any difficulty but when ensiling legumes no rain or dew should be on the crop or there will be an excessive percentage of moisture. If a legume crop is exceptionally heavy it may be wilted two or three hours in the sun but care is necessary to avoid over-wilting. Sometimes the practice is followed of ensiling in the afternoon what has been mowed in the morning.

In northern regions the freezing of silage gives considerable trouble, especially in upright or tower silos. Trench silos reduce or eliminate this difficulty. Where frozen silage sticks to the walls of the silo it should be removed as the silage is being taken from the silo. Otherwise it has a tendency to dry out and become mouldy. On the Dominion Experimental Station at Scott, Saskatchewan, where sunflowers are ensiled in a tower silo, the silage becomes frozen solid and very difficult to remove unless special methods are employed. The trouble has been corrected by putting into the silo 12 sheaves of cut oats, almost as ripe as when cut for grain, for every three loads of sunflowers of about $1\frac{1}{2}$ tons each. This makes a layer of 2 inches to 3 inches of oats about every foot in depth of silage. The silage freezes solid but can be removed easily in layers. Two men are said to be able to remove more silage in twenty minutes with this method than they could in over three hours without it. The blocks are stood up in the barn to thaw before feeding. This method, it will be remembered, has been used with sunflowers which no doubt contained a considerable content of moisture. If tried with other crops containing less moisture it should be commenced on a small scale owing to the danger of mould being developed beside the relatively dry straw.

Very little definite information is available on the losses which occur in making silage from various crops under different conditions. Frequently the total weight of the crop put into the silo is known but rarely are figures available of the weight of silage fed, the extent of the spoiled silage, the loss of liquid, and the amount of shrinkage due to fermentation. As silages contain widely varying percentages of moisture, depending upon the type and maturity of the crop, the amount of dry matter in the silage may range from below 15 to over 40 per cent. The composition and feeding value of the silage may also vary considerably.

It is not enough to put a large total weight of crop into the silo, the real problem is to secure a large amount of highly nutritious silage to feed from the silo. When it is considered that total losses in ensiling crops may range from less than 10 per cent to over 30 per cent, it is obvious that every care should be given to proper methods. These methods have been discussed in this bulletin under the chapters dealing with the various crops.

COMPARATIVE ADVANTAGES OF SILAGE AND FIELD CURED FODDER

Some of the advantages and disadvantages of the ensilage system, as experienced by private farmers, are presented on page 13 of this bulletin. It is interesting to examine in somewhat greater detail other points involved in the ensiling of crops as compared with field curing and storing in the barn in an air-dried condition. A study of these points will explain the relative advantages of the two systems.

CORN SILAGE VERSUS CORN FODDER

Although both these methods of harvesting corn involve the loss of some of the nutritive value of the crop there is less loss when it is ensiled. However, there is a larger investment required for ensiling and hence it is usually considered that 6 acres of corn, or 15 head of mature cattle are necessary to warrant it.

When corn is cured in the field as fodder there is greater mechanical loss of various parts of the plant as well as loss by leaching. Besides, when fed to cattle there is considerable waste by the animals rejecting the larger butt ends of the stalks.

While field curing of corn results in greater losses than ensiling, it is commonly used where small acreages are grown.

Even when ensiled there is some loss by fermentation and leaching. The amount of leaching depends upon the maturity of the crop and to some extent on the condition of the silo. The loss of liquid seldom reaches 5 per cent and usually is much less. The composition of the juice which drained from two small experimental silos showed an average content of 0·04 per cent of protein,

0·22 carbohydrates, ·0025 per cent fat and ·09 per cent ash. Considering both the low percentage of nutrients in the juice as well as the small amount which drains away, it is apparent that this is not a serious source of loss.

While different investigators have reported widely varying losses of dry matter from ensiling and field curing of corn, it may be said that ensiling results in a loss of approximately 15 per cent dry matter while field curing entails a loss of approximately 25 per cent. Besides, field curing occasions greater losses when feeding.

Some nutrient material seeps from the upper to the lower depths of the silage in the silo. Shaw, Wright and Daysher of the United States Department of Agriculture record losses in corn silage in the upper part of the silo of 12·74 per cent dry matter and 2·46 per cent protein. In the lower part of the silo the loss of dry matter was only 4·70 per cent while there was an actual gain of 15·19 per cent in the protein. It is wise to avoid an undue amount of seepage by allowing the crop to reach a sufficiently advanced stage of maturity.

The cost of ensiling corn is considerably greater than the cost of utilizing it as fodder. This is due chiefly to the cost of the silo, which may be estimated at from $150 to $300 for a 100-ton stave silo and the cost of the extra machinery required. The cost of a silage cutter may be estimated at approximately $350 but this machine is frequently owned co-operatively by several farmers. Further information in regard to the cost of ensiling corn by different methods is presented on page 27 of this bulletin.

ALFALFA SILAGE VERSUS ALFALFA HAY

While red clover may be made into good silage much more easily than can alfalfa and in some parts of Canada is rather extensively used in this manner, certain experiments have been conducted on the Central Experimental Farm at Ottawa comparing alfalfa as silage with alfalfa hay. The results of these experiments are somewhat applicable to red clover, sweet clover and other similar legume crops.

When alfalfa was made into hay there was an average loss of 10·73 per cent of dry matter of which somewhat over one-third consisted in loss of leaves. Under adverse weather conditions this loss may be much greater.

The cost of ensiling alfalfa is somewhat greater than the cost of making it into hay. It cost $5.69 an acre in 1932 to ensile a crop of alfalfa yielding 6·8 tons of silage as compared with $3.55 an acre to make hay, yielding 2·1 tons per acre. This is equivalent to a cost of 84 cents per ton to ensile and $1.69 per ton to make into hay. However, as the silage contained a much smaller percentage of dry matter the cost of ensiling a ton of dry matter was $3.41, while the cost of making it into hay was oly $2.15.

While the actual cost of ensiling is somewhat greater than the cost of making into hay the difference is not very considerable. Furthermore, crops may be ensiled under weather conditions which would make good hay curing impossible. Besides silage involves less losses in harvesting and requires less storage space than hay. It is not intended to recommend ensiling any considerable proportion of the alfalfa crop but if proper methods are employed some of this crop might be used in this manner. Red clover and sweet clover which may be ensiled more easily than alfalfa might be more extensively used in this way.

COMPARATIVE STORAGE SPACE REQUIRED FOR SILAGE AND FIELD CURED CROPS

Silage may be stored in a smaller space than an equivalent amount of field cured crop. Table 11 shows the comparative weight per cubic foot of dry matter and the storage space required at the time of harvesting per ton of corn silage, hay and mangels. For more detailed information on the weight of silage at different depths in the silo the reader is referred to page 71 of this bulletin.

TABLE 11.—STORAGE SPACE REQUIRED FOR DIFFERENT CROPS

Crop	Average weight per cubic foot	Cu.ft.space required per ton	Per cent dry matter	Cu. ft. space required per ton dry matter
Corn silage	35	57·1	25	228
Hay	3·5	580·0	80	725
Mangels	50	40·0	10	400

On the basis of the dry matter contained in the above feeds, corn silage could be stored in less space than mangels and in much less space than hay. One ton of dry matter of corn silage could be stored in 228 cubic feet while mangels required 400 and hay as high as 725 cubic feet. If the comparison be made with the crops as harvested, mangels require the least space but as this crop contains only ten per cent dry matter greater storage space is necessary on the dry matter basis.

COMPARATIVE YIELD AND COST OF PRODUCING VARIOUS FODDER CROPS

Certain fodder crops cost considerably more than others to produce. Yields vary widely in different localities throughout Canada. For these reasons a crop which can be produced satisfactorily in one region may be entirely unsuitable in another.

In order to obtain information on this important problem an experiment has been conducted for several years on seven Dominion Experimental Farms throughout Eastern Canada. Corn, sunflowers, roots and a mixture of oats, peas and vetches have been grown on one acre or more of land and the yields and cost of production compared with hay. For a complete statement on the cost of producing farm crops the reader is referred to Bulletin No. 168, Cost of Producing Farm Crops in Eastern Canada, and to Bulletin No. 159, Cost of Producing Farm Crops in the Prairie Provinces. Table 12 presents the average yield and cost of production per acre during the years from 1922 to 1934.

Corn has given high yields as will be seen in table 12 at Kentville, N.S., and at Ottawa, Ontario. At the other stations the yields were lower particularly at Kapuskasing, in northern Ontario, and at Lennoxville, Quebec.

Sunflowers have produced fairly high yields at all the stations but the cost of production has been slightly higher than that of corn. Fairly satisfactory yields were obtained from the mixture of oats, peas and vetches at a cost per acre considerably lower than that for the intertilled crops. Roots have yielded well at all the stations but the cost has been very high. The hay crop has been produced at the lowest cost per acre and as will be seen from the following tables, at the lowest cost per ton of dry matter and per ton of digestible nutrients. Of course, it is impossible to provide a balanced feed ration by growing hay alone and other crops must of necessity be produced. Silage crops produce succulent feed which is considered of great importance for winter feeding by many live-stock men.

YIELD AND COST OF PRODUCING DRY MATTER IN VARIOUS FODDER CROPS

As the percentage of dry matter varies considerably among different crops, a comparison of the yield and cost of producing a ton of dry matter of each crop is presented in table 13. This information has been secured from experiments conducted on seven Dominion Experimental Farms in Eastern Canada.

TABLE 12—YIELD AND COST OF PRODUCING VARIOUS FODDER CROPS ON THE DOMINION EXPERIMENTAL FARMS IN EASTERN CANADA

Station	No. of years average	Average yield per acre					Average cost per acre					Average cost per ton				
		Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay
		tons	tons	tons	tons	tons	$	$	$	$	$	$	$	$	$	$
Nappan, N.S.	12	14·35	15·39	6·01	18·36	2·35	50 72	53 57	47 29	59 54	20 31	3 53	3 48	7 87	3 24	8 64
Kentville, N.S.	10	16·68	18·96	7·32	18·08	2·60	54 68	59 35	44 60	69 37	22 06	3 28	3 13	5 68	3 84	8 48
Fredericton, N.B.	11	(1)12·31	(2)13·66	8·16	(3)19·27	1·94	56 27	49 72	50 15	51 94	20 81	4 57	3 64	6 15	2 70	10 72
Ste. Anne, Que.	11	13·26	17·29	.....	18·45	2·83	42 65	46 51	.....	66 95	20 36	3 22	2 69	.....	2 62	7 19
Lennoxville, Que.	11	10·52	(4)14·22	7·95	19·06	2·47	38 40	42 69	37 75	54 29	19 51	3 65	3 00	4 76	2 89	7 90
Kapuskasing, Ont.	11	(4) 7·02	10·65	(4) 4·43	.....	1·42	44 71	35 98	34 26	.....	14 54	6 37	3 38	7 73	.....	10 24
Ottawa, Ont.	13	17·19	19·52	(2) 6·37	22·62	3·61	52 12	55 40	38 08	66 45	24 65	3 03	2 84	6 32	2 94	6 83
Av. of all stations.	.....	13·05	15·67	6·71	19·31	2·46	48 51	49 03	42 02	61 42	20 32	3 72	3 13	6 26	3 18	8 26

(1) 9 year average. (2) 6 year average. (3) 5 year average. (4) 8 year average.

TABLE 13—YIELD AND COST OF PRODUCING DRY MATTER IN VARIOUS FODDER CROPS ON THE DOMINION EXPERIMENTAL FARMS IN EASTERN CANADA

Station	Average per cent dry matter					Average yield of dry matter per acre					Average cost per ton of dry matter				
	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots*	Clover hay*	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay
						tons	tons	tons	tons	tons	$	$	$	$	$
Nappan, N.S.	17·3	16·4	23·0	9·4	78·5	2·48	2·52	1·38	1·73	1·84	20 45	25 23	34 27	34 42	11 04
Kentville, N.S.	15·5	15·5	22·0	9·4	78·5	2·59	2·94	1·61	1·70	2·04	21 11	20 19	25 84	40 80	10 81
Fredericton, N.B.	14·4	13·7	18·3	9·4	78·5	1·77	1·87	1·49	1·81	1·52	31 79	26 59	33 66	28 70	13 69
Ste. Anne, Que.	15·9	15·5	.....	9·4	78·5	2·11	2·68	.....	1·73	2·22	20 21	17 35	.....	38 70	9 17
Lennoxville, Que.	14·2	14·4	25·0	9·4	78·5	1·49	2·05	1·99	1·79	1·94	25 77	20 83	18 97	30 33	10 06
Kapuskasing, Ont.	14·0	13·0	18·0	9·4	78·5	·98	1·38	·80	.....	1·11	45 62	26 07	42 83	.....	13 10
Ottawa, Ont.	18·6	18·9	26·6	9·4	78·5	3·20	3·69	1·69	2·13	2·83	16 30	15 01	22 53	31 20	8 71
Average of all stations.	15·7	15·3	22·2	9·4	78·5	2·09	2·45	1·49	1·81	1·93	23 21	20 01	28 20	33 93	10 53

* Average dry matter used for roots and clover hay at all stations.

On the basis of dry matter, clover hay was produced very much more cheaply than any of the other crops on all of the Dominion Experimental Stations throughout Eastern Canada. Roots, on the other hand, were the most expensive crop to produce. In places where corn grows satisfactorily, it costs approximately the same as sunflowers. In cooler regions where sunflowers thrive comparatively better, they are less expensive than corn. They never make, however, quite as palatable feed. Hay crops, or a mixture of oats and peas, under such conditions, may prove more economical.

Where silage crops can not be grown successfully, small acreages of roots may be grown to advantage. They are particularly popular in the Maritime Provinces. The tops may be ensiled, as mentioned in the section of this bulletin dealing with mangels.

COST OF PRODUCING DIGESTIBLE NUTRIENTS IN VARIOUS CROPS

Neither the total yield nor the amount of dry matter affords a satisfactory basis for comparing the value of various crops. Other methods have been used such as a comparison of the net energy value, starch equivalent or the total digestible nutrients. Table 14 gives information on the comparative yield and cost of producing the total digestible nutrients in the various crops.

Clover hay is the cheapest source of digestible nutrients among the crops which have been compared while roots have been the most expensive. Where corn grows well, as at Ottawa, it produces a large amount of feed per acre at a reasonably low cost.

The high cost of producing roots is due chiefly to their high labour requirements. Unlike silage crops, however, they do not require any extra expensive machinery. Where ample family labour is available or where labour is avail-

TABLE 14—YIELD AND COST OF PRODUCING TOTAL DIGESTIBLE NUTRIENTS IN VARIOUS FODDER CROPS ON THE DOMINION EXPERIMENTAL FARMS IN EASTERN CANADA

Station	Average yield per acre					Yield of total digestible nutrients per acre					Cost per ton of total digestible nutrients				
	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay	Corn silage	Sunflower silage	Oats, peas and vetch silage	Roots	Clover hay
	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	$	$	$	$	$
Nappan, N.S.	14·35	15·39	6·01	18·36	2·35	1·665	1·446	·865	1·358	1·076	30 46	37 05	54 67	43 84	18 88
Kentville, N.S.	16·68	18·96	7·32	18·08	2·60	1·734	1·687	1·010	1·337	1·191	31 53	35 18	41 19	51 88	18 52
Fredericton, N.B.	12·31	13·66	8·16	19·27	1·94	1·181	1·079	·930	1·426	·889	47 65	46 08	53 92	36 42	23 41
Ste. Anne, Que.	13·26	17·29	.....	18·45	2·83	1·418	1·539	.....	1·365	1·296	30 08	30 22	.....	49 05	15 71
Lennoxville, Que.	10·52	14·22	7·95	19·06	2·47	·988	1·180	1·240	1·410	1·131	38 87	36 18	30 44	38 50	17 25
Kapuskasing, Ont.	7·02	10·65	4·43	.....	1·42	·653	·798	·500	.....	·650	68 47	45 09	68 52	.....	22 37
Ottawa, Ont.	17·19	19·52	6·37	22·62	3·61	2·131	2·127	1·080	1·674	1·653	24 46	26 05	35 26	39 70	14 91
Average of all stations.	13·05	15·67	6·71	19·31	2·46	1·396	1·408	9·938	1·428	1·127	34 75	34 82	44 80	43 01	18 03

Correction for Table 15

Average Cost of Producing Corn Silage

Manure - 40 per cent of 20 tons at $1.50 per ton	12.00
Seed - 1/2 bushel at $1.56 per bushel	.78
Manual Labour - 77.2 hours at 15.1 cents	11.66
Tractor Labour - 10.55 hours at 80.4 cents	8.48

Third sentence below table - change 80 cents to 85 cents.

able at very low prices, it is possible that roots might be more suitable than silage. It is doubtful, however, if it would be advisable to grow such an acreage of roots as to make it necessary for the farmer to hire extra, high priced labour. Under most conditions mangels are a more suitable root crop than turnips as they produce slightly larger yields and keep better in storage. Furthermore, in some localities club-root and brown-heart have forced farmers to discontinue growing turnips. These diseases do not affect mangels.

COST OF PRODUCTION AND RETURN VALUE OF CORN SILAGE

In calculating the cost of producing crops such items as use of land and buildings, share of cost of manure, seed, machinery, twine and labour are included. In table 15 is presented an itemized statement of the average cost per acre, cost per ton and return value for corn silage produced on the Central Experimental Farm, Ottawa, during the years 1931 to 1943 inclusive.

TABLE 15—AVERAGE COST OF PRODUCING CORN SILAGE

Item	Statement	Amount
		$
Use of land and buildings	Rent or interest on value plus taxes and upkeep	4 50
Manure	40 per cent of 18 tons at $1.50 per ton	12 00
Seed	½ bushel at $1.44 per bushel	78
Machinery	Including ensiling outfit	5 85
Manual labour	77·2 hours at 14 cents	11 66
Horse labour	37·7 hours at 8 cents	3 01
Tractor labour	10·55 hours at 74 cents	8 48
Total cost per acre		46 28
Yield per acre	17·98 tons (19·22 per cent dry matter)	
Cost per ton	$2·57	

The average cost of producing corn silage for the years 1931 to 1943 inclusive with a yield of 17·98 tons, has been $46.28 per acre or $2.57 per ton. Where the yield varies from this average the difference in the total cost per acre affects the harvesting operations, including the cost of loading, hauling and ensiling the crop, and amounts to approximately 85 cents per ton. Thus, for every ton of increase or decrease from the yield of 17·98 tons per acre the figure of $46.28 will be raised or lowered by 80 cents. Therefore, if a heavier yield is secured the cost of production per acre is increased only a small amount, while the cost per ton of silage is materially reduced.

RETURN VALUE OF CORN SILAGE

It is difficult to place a value on silage. As it is fed to livestock and not sold on the market, it is necessary to estimate its value in comparison with the value of some other marketable crop used for a similar purpose. Since silage is usually substituted for a certain amount of hay in a ration the method commonly used to determine its return value is to compare silage with hay on the basis of their dry matter content and their respective feeding values. When corn silage has a dry matter content of 25 per cent, it is customary to give it a value on the basis that 300 pounds of silage is equal to 100 pounds of hay. When the silage contains less dry matter it should be given a lower valuation. Accordingly, if it contained only 20 per cent of dry matter it would require 375 pounds of silage to be equal to 100 pounds of hay. It is difficult to describe, exactly, the stage of maturity of corn when it contains various percentages of dry matter. However, as an approximate guide, when the corn at Ottawa is in the dough stage, it contains about 25 per cent dry matter, when in the milk stage it contains 20 per cent, and when in the silking stage it contains about 17 per cent of dry matter.

Using this method of valuing corn silage, which gives it a value of $2.15 per ton, it will be seen that there has been a small loss during the twelve-year period, 1931 to 1943. It should be pointed out, however, that the market price of hay, upon which the value of silage was based, was very low for this period, averaging only $8.18 per ton. Even at this low valuation the crop had a rather high return value of $38.66 per acre. As the market for hay has declined to such an extent in recent years due to the introduction of trucks, tractors and automobiles, the valuation of silage based on the market price of hay is not very satisfactory, the hay itself having become a product of considerably reduced market value.

It will be observed in table 15 that the cost of manure is one of the chief items of expense in connection with the cost of producing silage. The charge of $1.50 per ton for manure is based on $1 per ton for the manure itself, and 50 cents per ton for the cost of applying it. If manure was considered as a by-product on the farm and no valuation placed upon it, the charge for manure would be only 50 cents per ton rather than $1.50, thus reducing the total cost per acre of this item from $12.00 to $4.00, a reduction of $8.00. This would reduce the total cost per acre for the crop from $46.28 to $38.28, thus leaving a slight profit even with the market price of hay much lower than that received in previous years. Moreover, where sufficient family labour is available on the farm, the actual cash expenditure for the production of the silage would be very materially reduced. It will be seen, therefore, that under favourable conditions corn silage is a profitable crop to grow.

For more detailed information regarding the cost of producing crops the reader is referred to Bulletin No. 168, New Series, " Cost of Producing Farm Crops in Eastern Canada," which may be secured from the Publicity and Extension Division, Department of Agriculture, Ottawa.

ADAPTABILITY OF THE SILO TO DIFFERENT PARTS OF CANADA

MARITIME PROVINCES

Of the 45,827 silos in Canada, in 1931, only 490 were located in the Maritime Provinces. Only 44 silos were reported in Prince Edward Island, 277 in Nova Scotia and 169 in New Brunswick. As corn is the principal crop used for silage in Eastern Canada the acreage of this crop in a district is some indication of the popularity and adaptability of the silo. The Dominion Bureau of Statistics reported 600 acres devoted to fodder corn in 1941 in Prince Edward Island, 600 acres in Nova Scotia and 1,100 acres in New Brunswick. These acreages are small when it is considered that 419,000 acres of fodder corn were grown that year in Canada. The production of silage has not become popular in the Maritime Provinces. This is due to the unfavourable climatic conditions for the production of high yields of corn, to the fact that other crops have not been used to any extent as silage, and to the high cash outlay necessary for silage production. As the Dominion Experimental Farms are located in many of the more important agricultural regions throughout Canada, it may be of interest to present the opinions of the Superintendents of these stations on the adaptability of the silo, and the silage crops recommended in these regions.

Dr. J. A. Clark, Superintendent of the Dominion Experimental Station at Charlottetown, P.E.I., writing in regard to the silage situation in that province, is of the opinion that farmers who have the equipment should grow silage crops. He recommends, for that province, corn, mixed grain, clover hay and soybeans, the latter to be mixed with corn or mixed grain.

In most parts of Nova Scotia silage has never been very popular and does not appear to be increasing in favour. Mr. W. W. Baird, Superintendent of the Dominion Experimental Farm at Nappan, N.S., prefers swedes rather than silage made from corn or sunflowers. With his own labour the farmer can pro-

duce and store his roots without any cash outlay, such as is required for silage crops. However, where there is a large acreage of hay as well as a silo and equipment to handle it, Mr. Baird believes that some of this grass and clover crop may be ensiled to advantage.

In the Annapolis and Cornwallis Valleys of Nova Scotia the silo is more popular than in other parts of that province. Mr. A. Kelsall, Superintendent of the Dominion Experimental Farm at Kentville, N.S., recommends the use of the silo, ensiling either corn or clover. When there is a surplus of apples these, also, may be ensiled while apple concentrate may be employed in place of molasses as a preservative for legumes if the prices are comparable.

Mr. C. F. Bailey, Superintendent of the Dominion Experimental Station at Fredericton, N.B., recommends that large dairy farmers, especially those selling fluid milk, should have a silo. The most suitable crops to ensile in New Brunswick are red clover and alsike clover. Corn will grow fairly satisfactorily under favourable conditions in the river valleys but in most regions it does not give a sufficiently large yield. Sunflowers yield better than corn but are not very palatable. The mixture of oats, peas and vetches does not yield a sufficient tonnage to justify its use as silage. The chief reason for the lack of popularity of the silo in New Brunswick is the high cost of the equipment necessary to produce silage and the relatively low yields of the crops formerly used for silage. Now that clover is employed successfully for silage, the silo may become more popular. The growing of roots is recommended provided their production does not involve the hiring of extra labour. Due to club-root and brown-heart diseases being very prevalent in turnips in New Brunswick, mangels is the root crop recommended.

SILAGE IN QUEBEC AND ONTARIO

Silage is used most extensively in Canada in the provinces of Ontario and Quebec. The silo is particularly popular in Ontario where, in 1931, there were 35,716 or 78 per cent of all the silos in Canada. In Quebec it is estimated that there are 6,138 silos or 13 per cent of the country's total. It will be seen, therefore, that 91 per cent of the silos in this country are used in Ontario and Quebec. In 1941 Ontario produced 295,000 acres of fodder corn and Quebec 68,000 acres, which indicates to some extent the use which is made of silage in these two provinces. Climatic conditions do not favour the production of corn in Quebec to the same extent as in Ontario, which accounts for the silo being less popular in that province.

The silo is used to some extent in Quebec, however, and Mr. J. E. Montreuil, Superintendent of the Dominion Experimental Station, L'Assomption, Que., states that there has been an increase in the number of silos in the district, immediately north and east of Montreal which is served by the L'Assomption Station. Corn and alfalfa are the most satisfactory crops to ensile in this district. The yield of corn at the Experimental Station is 17½ tons per acre, although the average yield for the district is only 10 to 12 tons per acre. With proper varieties and better cultural methods the average yield can be increased. Mr. Montreuil believes that a silo is a good investment on any farm with at least 12 to 15 cows. He suggests that wooden stave or concrete silos are the most suitable for this district and it is better to build two silos of small diameter than one large one because with a large silo it is impossible to feed sufficient each day to prevent spoilage.

Mr. J. A. Ste-Marie, Superintendent of the Dominion Experimental Station at Lennoxville, Que., which serves the Eastern Townships of Quebec, recommends the ensiling of grass and clover. This will provide cheap, succulent feed and provide an opportunity of harvesting this crop in wet years when proper haymaking may be impossible. Corn does not produce economical yields in this part of Quebec and while sunflowers yield better they are not very palatable and are not regarded with much favour.

In the lower St. Lawrence district of Quebec, Mr. J. R. Pelletier, Superintendent of the Dominion Experimental Station at Ste. Anne de la Pocatiere, reports few silos in that region. A mixture of corn and sunflowers, and more recently grasses and legumes, has been recommended for silage along with the production of roots. Owing to the expense, however, only the root crop has gained in popularity in that region.

Mr. A. Belzile, Superintendent of the Dominion Experimental Station at Normandin, Quebec, recommends the use of legumes for silage in the district served by his Station.

It will be seen, therefore, that in some sections of Quebec silage is not used to any considerable extent. Throughout the province, however, there are sections which produce silage crops fairly satisfactorily. In a questionnaire sent out to many representative farmers in Quebec, 157 of them grew an average of 7½ acres of corn for silage. Others used sunflowers, oats, peas and vetches and red clover as the silage crop.

Ontario is the stronghold of silage production in Canada. Climatic conditions in the older developed parts of the province favour the growing of corn. Mixed farming is widely practised and silage is used as a large part of the forage ration for livestock. The great silage producing area of the province is in the western and central section bordered on the south by Lake Ontario and Lake Erie and north to Lake Huron, Georgian Bay and the counties of Muskoka and Haliburton. The silo is also popular in eastern Ontario.

Corn is the principal silage crop in Ontario, with 295,057 acres of fodder corn being grown in 1941. As there were 35,716 silos in Ontario this makes an average of 8·26 acres of corn for each silo. Part of this acreage may be used for field cured fodder but the majority is used for silage. Sweet clover, oats and peas, red clover and sunflowers are also used as silage in Ontario to a lesser extent.

Notwithstanding the objections raised against corn for silage on the grounds that it is expensive to produce, it has many advantages in Ontario. On soils to which it is adapted larger yields per acre may be obtained from corn than from hay, roots or grain. In dry years, corn gives better results than other crops. On the Central Experimental Farm at Ottawa where the average yield of corn for silage during the last 20 years has been 17·60 tons per acre, the lowest yield ever experienced during this period has been 13·03 tons. This heavy yield, especially in a poor year, is an excellent insurance against a shortage of feed. In fact, there has never been a failure with this crop.

While it is true that corn requires considerable labour, it comes at a time when it does not conflict with other crops. Being seeded and harvested after grain crops, it distributes the labour throughout the season very satisfactorily.

Mr. H. F. Murwin, Superintendent, Dominion Experimental Station for southwestern Ontario, located at Harrow, recommends the use of the silo on every farm where livestock is raised. Silos are on the increase in this district. It is the centre of the greatest seed corn producing region in Canada, and naturally corn is also the crop most extensively used for silage. Silage produced from this type of corn has exceptionally good quality.

In northern Ontario, Mr. Smith Ballantyne, Superintendent of the Dominion Experimental Station at Kapuskasing, reports that silage is not used to any appreciable extent in that region. Sunflowers and clover are used as silage to a limited extent.

SILAGE IN THE PRAIRIE PROVINCES

The three Prairie Provinces of Manitoba, Saskatchewan and Alberta, being primarily grain producing areas, the production of silage is relatively of little importance. In Manitoba only 468 silos are reported in the 1931 Dominion Census, while 544 are located in Saskatchewan and 433 in Alberta. A fairly large acreage of corn is produced in Manitoba, 95,000 acres for grain and 37,000 acres for fodder in 1941.

Mr. M. J. Tinline, Superintendent of the Dominion Experimental Farm at Brandon, Manitoba, states that the use of silage is increasing in the vicinity of Brandon. This increase may be attributed, to some extent at least, to the development of the trench silo, which is proving very economical and satisfactory. The tendency in the past has been to use hay and green feed almost entirely as forage for livestock but silage is being used to some extent. Wherever it is important to get the highest possible tonnage of good feed for livestock silage should be produced, but where hay can be produced in ample quantities for livestock requirements farmers may find they can use their labour to better advantage by increasing the acreage of hay.

Mr. W. R. Leslie, Superintendent of the Dominion Experimental Station at Morden in southern Manitoba reports that the corn acreage has increased remarkably during the past few years. The trench silo is less expensive than is the upright silo, is quite satisfactory, and is gaining in favour. The Station officials recommend building a silo where 5 acres or more of corn are grown.

In Saskatchewan the production of silage has never become popular, and apparently is decreasing in favour. Mr. W. H. Gibson, Superintendent of the Dominion Experimental Farm at Indian Head, favours the use of oat sheaves rather than silage for dairy cattle. Mr. M. J. McPhail, Superintendent of the Dominion Experimental Station at Melfort does not think farmers have sufficient labour to ensile crops. Mr. G. D. Matthews, Superintendent of the Dominion Experimental Station at Scott, is not very favourable to the growing of a special crop for silage, but rather prefers to ensile a part of the crop as a feed reserve for drought years. Mr. L. B. Thomson, Superintendent of the Dominion Experimental Station at Swift Current, does not recommend the ensiling of crops in that region.

A similar condition exists in Alberta to that found in Saskatchewan. Mr. F. H. Reed, Superintendent of the Dominion Experimental Station at Lacombe, Dr. W. H. Fairfield, Superintendent of the Dominion Experimental Station at Lethbridge, and Mr. W. D. Albright, Superintendent of the Dominion Experimental Station at Beaverlodge, report that silage is not popular in Alberta and its production is not recommended by the Dominion Experimental Stations in the province. Where silos are used, the trench silo is the most prevalent type. At Lacombe, oats for green feed or hay is recommended and in some instances silage for feeding during the period of summer drought. At Lethbridge roots are suggested as being more suitable than silage in the irrigated section.

SILAGE IN BRITISH COLUMBIA

The 1931 census reports 2,038 silos in British Columbia. In the vicinity of Saanichton, Mr. J. J. Woods, Superintendent of the Dominion Experimental Station, reports that the crop most commonly used for silage is wheat, peas and vetches. This mixture consists of 60 pounds of beardless wheat, such as Sun, 30 pounds of winter peas and 30 pounds of common spring vetches, seeded at the rate of 2 bushels per acre in the fall during the first ten days of October. Fall seeding enables the crop to take advantage of the heavy fall and winter precipitation. The tower type of silo is generally used on Vancouver Island.

Mr. R. C. Palmer, Superintendent of the Dominion Experimental Station at Summerland, reports that the use of silos is increasing in the Okanagan Valley. The upright or tower type is recommended as soils are not suitable for the construction of trench silos. Corn of the Golden Glow, Northwestern Dent, Leaming or Longfellow variety is recommended for silage. Apples mixed with alfalfa hay are also recommended for silage. Silos are recommended by the Summerland Station where dairymen have six or more cows.

Mr. W. H. Hicks, Superintendent of the Dominion Experimental Farm at Agassiz, recommends the production of silage and says, "It is a succulent feed,

uniform, inexpensive, handy to feed and takes little storage space." Corn, clover and oats and peas are used chiefly as the silage crop. The first cutting of red clover is quite extensively used in this region for silage. The upright silo is preferred to the trench silo.

Mr. R. J. Newton, Superintendent of the Dominion Experimental Station at Prince George, recommends the use of clover and grass for silage.

It will be seen from this discussion that, while the silo is widely used throughout Canada, it is much more popular in some sections than in others. In Ontario silage is very popular, and in spite of the high cost of machinery and labour it continues to take a prominent place as a forage feed. In parts of Quebec and British Columbia silage is used quite considerably, while in the Maritime Provinces and on the Prairie it is not so popular. In certain sections of all provinces, however, some silage is produced and it may be considered a crop of considerable national importance. The use of grass and clover for silage has become increasingly popular in recent years.

TYPES OF SILOS

Detailed information on the construction of silos may be obtained by writing the Architect, Central Experimental Farm, Ottawa. It may be a matter of interest, however, to present in this bulletin a list of the different types of silos which are in more or less common use together with some brief comments on their adaptability.

The first silos were made below ground and were the so-called pit or trench type. Later, silos were built above ground, the first types being of square construction. Considerable loss of silage took place in the corners of these square silos and it was difficult to build them to withstand the tremendous pressure exerted on the walls. For these reasons the square silos have been displaced almost entirely by cylindrical and octagonal types.

THE STAVE SILO

Among the cylindrical types of silos, the stave is the most commonly used. It may be built of Douglas fir, Western larch or Western red cedar staves, 2 inches thick, 6 inches wide and the required length, depending on the height of the silo. In order to make the silo air-tight the edges of the staves must be carefully fitted together. Several types of finish on the edges will produce the desired results. Slightly bevelled edges are perhaps most common and least expensive. In the better types tongued and grooved staves are used and occasionally knuckle joints or lap joints are employed. The staves are placed in an upright position and tightened together by means of hoops of $\frac{5}{8}$-inch iron, threaded at the ends and tightened by means of nuts drawing the rods or hoops through a buckle or clip. Openings of about 18 inches by 24 inches must be left in the side of the silo through which the silage may be removed. It is very important, also, to anchor the silo to the barn by means of wires or cables. If this is not done there is great danger of the silo being blown over, many unsupported silos being badly damaged during wind storms. It is desirable but not absolutely necessary to build a roof over the silo.

The stave silo may be built at home from lumber purchased from the local saw mill or may be purchased from several companies which build them commercially. The commercially built silos are usually treated with a coal tar preparation for the purpose of preserving the wood. Stave silos may be built for $150 to $500, depending upon the availability of lumber and hoops and the amount of home labour used. It is the cheapest silo to build from the standpoint of initial outlay but is not as durable as many of the other types.

THE OCTAGONAL OR EIGHT-SIDED SCANTLING SILO

Where lumber can be purchased at reasonable prices it may be advantageous to build the scantling type of silo. It may be constructed entirely of wood and nails. It is considerably more rigid and durable than the round stave silo and the construction is more simple.

The eight-sided scantling silo is used where lumber is cheap.

This silo is built in the form of an octagon with eight sides constructed of layers of 2- by 4-inch studding laid on the flat side. To begin the construction, four scantlings are laid opposite to one another and bolted to the foundation. In the next layer 4 pieces are laid on the other four sides of the octagon with the ends lapping over and nailed to the ones below. This process

is then continued to the top. When the scantlings are in place the inside of the frame must be sheathed. If desired it may be sheathed on the outside also. This provides an air space which helps to prevent freezing and makes a better wall but at considerably greater expense. Feed doors must be built in and a roof should be constructed.

The scantling silo in most districts is more expensive than the stave type. At Ottawa the material alone for a 14 x 28 foot silo cost in 1933 about $300. With this type of silo great care must be taken in filling as it is difficult to pack the silage thoroughly in the corners to prevent spoiled silage.

SOLID CONCRETE OR MONOLITHIC SILO

Next to the stave silo the solid concrete type is in most general use in Eastern Canada. It is very durable and the action of the acids in the silage on the cement walls is slight, provided that proper mixtures of sand, gravel and cement are employed. The walls are usually made about 6 inches thick of a 1 to 6

The solid concrete silo is very durable and is a type which is used extensively in many districts.

cement and gravel mixture, reinforced with steel wire or rods. Where plenty of gravel is at hand and not too expensive the solid concrete silo may be built at reasonable cost. The cost is about $400 for a 14 x 28 foot silo. It is simply constructed, the building of the forms into which to pour the concrete being the most difficult part of the process. These forms, however, may quite often be rented.

CEMENT BLOCK SILO

The cement block silo is slightly more expensive than the solid concrete but is very serviceable. It is easier to build in that no forms are necessary but scaffolding and a hoist are required. Various types of blocks are used but a hollow type is preferred on account of the air space which reduces the conductivity and the amount of freezing. A skilled mason is required to lay the blocks in order to make the proper curvature of the silo wall and to provide sufficient reinforcing or binding together at the edges of the blocks.

OTHER CONCRETE SILOS

Several other types of concrete silos have been built but are not used to any considerable extent. The concrete stave silo is made of cement slabs made in various patterns. The slabs are usually about $2\frac{1}{2}$ feet long by 1 foot wide and 2 inches thick. The slabs are made to interlock together at the edges and the structure is reinforced with hoops embedded in the cement in the interspaces. Cement plastered silos are sometimes used. These are made by plastering several coats of cement over metal lath held in place by a framework. When complete the metal lath forms the central reinforcement for a cement wall 3 or 4 inches thick. This type is little used in Canada.

VITRIFIED TILE OR CLAY BLOCK SILOS

This type of silo is similar to the cement block but as the name implies the blocks are made of clay. This type is comparatively expensive from the standpoint of initial outlay, a silo of 14 x 28 feet dimensions costing approximately $500. They are very durable, however, and make a very attractive and suitable silo. The blocks are made by commercial companies who supply all the materials for the complete construction of the silo. Skilled labour is required for building this type of silo.

BRICK AND STONE SILOS

Brick and stone are sometimes used where such materials are readily obtainable. Both materials make very good silos when properly constructed.

THE TRENCH SILO

As mentioned in the section of this bulletin dealing with the history of silage, the trench or pit silo was the type first used for ensiling crops. Failure to produce good silage was reported in many instances. These failures were due, no doubt, largely to a lack of knowledge of the ensilage processes and the conditions necessary to produce good silage. For this reason silage did not come into popular favour until the introduction of the tower or upright silo. This type with its much greater height and smooth sides provided for more thorough packing and caused less loss due to spoilage which was prevalent in corners and on rough sides of the trench silo.

Since the early trials with the first trench silos considerable experimental work has been undertaken and crops may now be ensiled with less danger of poor silage production. This is true of both upright and trench silos. Considering the high cost involved with the upright silo both from the standpoint of the initial expense of the silo itself as well as the cost of equipment and labour necessary to properly ensile the crop, the trench silo is much less expensive and in recent years has attracted considerable interest.

The trench silo has not been used to any extent in Eastern Canada. In the Prairie Provinces, however, and in the Western and Southern United States, this type has been used quite extensively. It has not been widely used in Eastern Canada, probably for the reason it has been felt that climatic conditions were unfavourable. There has not been a sufficient number used to demonstrate whether or not they are adapted to this part of the country. The precipitation

is approximately double that received in the Prairie Provinces which makes it difficult to secure proper drainage. Further experimental work and experience are necessary before this type of silo can be recommended for Eastern Canada.

Advantages of a Trench Silo

The trench silo has some advantages over the tower or upright type of silo. The cost of construction is considerably lower with the trench silo. A very small cash outlay is required as most of the cost involves only home labour and standard farm equipment. A trench silo is frostproof, windproof and fireproof. It can be built on short notice to meet an emergency need for a silo. Filling the trench silo may be done with a minimum of power and equipment. Crops have been successfully stored in trench silos without cutting with the ensilage cutter. This would be almost impossible with a tower silo due to the difficulty of getting the material into the tower silo and the fact that the material cannot be sufficiently packed to prevent spoilage.

Disadvantages of a Trench Silo

While the trench silo has many advantages it also has some disadvantages. Unless extreme care is exercised in handling the material, more spoilage is likely to take place in a trench silo than in the tower due to the square sides and the greater exposure of the silage on the surface. A trench silo must be located so that proper drainage may be provided. In sandy or gravelly soils the walls of a trench silo must be constructed of concrete or plank because such soils are very friable and crumbly and the walls will cave in if not reinforced. Although the trench silo has been used quite successfully in the Prairie Provinces, it is not yet known whether this type would be satisfactory in the more humid climate of Eastern Canada.

Locating the Trench Silo

A trench silo is often regarded as simply a hole in the ground and in some cases it is little more. However, it should be constructed so as to secure the greatest convenience and permanence at a minimum of cost.

The first and most important consideration is the location. It should be located as near to the stable as possible in order that the silage may be removed and fed conveniently. With a bank barn the trench may be dug so that the end is directly against the wall of the barn. A door may be placed through the stable wall supplying a direct connection between the stable and the silo. Where a concrete wall is used for the silo the side of the silo might run parallel to the stable wall. In fact the stable wall might be used as one side of the silo. Circumstances may not permit the location of the trench silo near the barn in which case the silage would have to be transported from the silo to the stable by means of a horse-drawn vehicle.

The trench should be located to provide adequate drainage. This is sometimes accomplished by constructing it on the side of a slope or gully. The trench in this case may be dug lengthwise at right angles to the slope with one end opening directly onto the side of the slope or gully. This will provide drainage and also allows for removing the silage by means of a wagon or sled which can be driven out of the silo on the ground level.

Where no such slope is available a tile drain may be installed leading from a low corner of the trench to a main drain or open ditch at some distance from the silo. If sufficient fall cannot be obtained to provide such drainage a small hole or sump may be dug in the corner of the trench and surplus liquid pumped out by means of a small cistern pump. Where the trench is dug in light soil drainage by seepage into the subsoil may be sufficient or where clay soil is underlain with sand or gravel a hole may be dug through the impervious clay and the water drained through it to the sand below.

Shape and Capacity of Silo

Although no definite dimensions are recommended for a trench silo the most common size of trench is one 8 feet deep, 8 feet wide at the bottom and 12 feet wide at the top with sufficient length to provide the required capacity. The reason for the trench being wider at the top than at the bottom is to provide a slope to the side walls and thus prevent caving. The sloping walls also provide for more thorough packing of the silage as the horse or tractor used for tramping can pass closer to the wall. For clay soils a slope of 1 foot in 4 is sufficient. In lighter soils, if no retaining wall is used, a greater slope would be advisable. Usually it is advisable to build the silo narrow and supply the required capacity by increasing or decreasing the length. A narrow trench results in less spoiled silage as sufficient can be fed off each day to prevent spoiling. It is also more easily covered if a cover is desired. In the event of the sides caving in they may be reconstructed without the trench becoming too wide.

The trench silo has been used most extensively in the Prairie Provinces of Canada. It entails a very small cash outlay. The above photograph shows a trench silo in the Dominion Experimental Station, Swift Current, Saskatchewan.

The length of the silo will depend upon the number of livestock or the amount of silage required. The average weight of a cubic foot of silage in a trench silo is 31 pounds. On this basis table 16 presents the weight of silage per foot of length for trenches of different sizes.

TABLE 16.—CAPACITY OF TRENCH SILOS PER FOOT OF LENGTH

Depth	Width of top	Width of bottom	Tons of silage per 1 foot length	Depth	Width of top	Width of bottom	Tons of silage per 1 foot length
feet	feet	feet		feet	feet	feet	
6	6	4	0·46	8	10	6	0·99
6	8	6	0·65	8	12	8	1·24
6	10	8	0·84	8	14	10	1·49

From table 16 the capacity of a trench silo of any length may be calculated, simply by multiplying the number of tons of silage per one foot of length, in a silo of the depth and width as listed, by the total length of the trench. The size of silo required to store enough silage for a herd of a given size may also be calculated from this table. The length of stable feeding period in Eastern Canada is approximately 200 days from November to May. A mature cow may be fed about 40 pounds of silage per day. For 200 days each animal would require 4 tons of silage. This amount multiplied by the number of animals to be fed and divided by the number of tons of silage per one foot of length will give the length of trench required for the herd.

Constructing the Trench Silo

The only equipment necessary for digging the trench is a plough, a horse scraper and a shovel or spade. With two teams and this equipment a farmer and one extra man can build an average sized trench silo in 5 or 6 days. A chain on the plough and scraper facilitates the handling of these implements. The fill from the trench may be deposited on the high side of the trench to provide a dam which may turn surface water away from the silo or it may be piled on either side of the trench to provide part of the side wall and add height to the silo without going so deeply into the ground. One end of the trench may be sloped similar to the sides but the other end should be built with a more gentle slope to allow for driving into the silo with wagon or sled to remove the silage.

The side walls of the trench silo should be made as smooth as possible by scraping with a spade or shovel. A silo built in this way may last for several years. For a more permanent structure, however, walls of concrete or stone may be built. It is suggested that walls of earth might be used for a few years and then later more permanent walls might be built. Figure 1 shows a diagram of a trench silo of comparatively cheap construction.

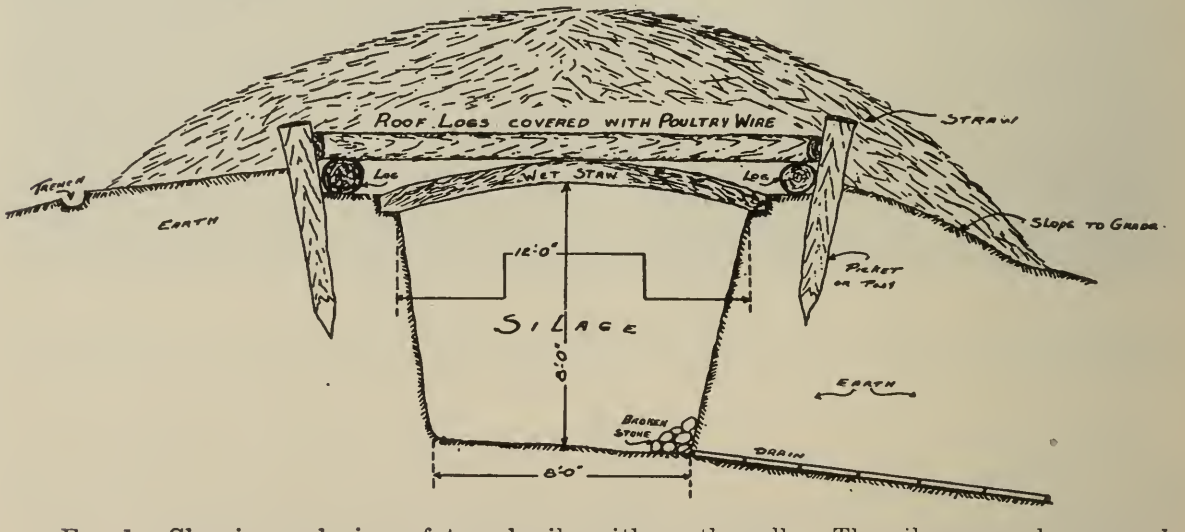

FIG. 1.—Showing end view of trench silo with earth walls. The silage may be covered with 8 inches of wet straw at the time of filling and after it has settled several weeks, a roof of logs, wire and straw may be built. Note drain from lower right-hand corner.

Digging the trench for the silo in figure 1 with plough and scraper will cost approximately 60 cents per ton capacity. At the Dominion Experimental Station, Swift Current, Saskatchewan, the total cost of excavation and roof for a 150 ton trench silo, 9 feet deep, 14 feet wide and 80 feet long was $98, made up as follows:

160 hours manual labour at 30 cents	$48 00
240 hours horse labour at 10 cents	24 00
Wire and straw roof	26 00
Total cost	$98 00

For approximately $100, therefore, a 150 ton trench silo may be constructed and on many eastern farms a smaller silo would fulfil the requirements with a corresponding reduction in cost. Moreover, almost the entire cost is for home labour, very little cash expenditure being involved. However, as mentioned previously, this type would last in Eastern Canada for only a few years and it might be desirable to build more permanently with concrete or stone walls. Where cement is used great care must be taken to use clean, sharp sand or gravel. Otherwise the cement will crumble and chip. A concrete mixture of 1 part cement, 2 parts sand and 4 parts gravel should be used. The wall should be about 4 inches thick and must be reinforced with wire or light steel bars. A stone wall is perhaps slightly cheaper and is quite suitable, while a concrete wall with stone filler is perhaps the cheapest of all and does not require skilled labour to build. Figure 2 adapted from Circular 93 of the North Dakota Agricultural College shows the three types of walls which might be used. The cost of these various types will depend upon the availability of sand, gravel, stone and cement.

Where the water level is too high or where for some other reason it is impossible to excavate as deeply as recommended above it is possible that a silo partly below ground and partly above ground would be more satisfactory. In fact even where these objections are not encountered this type of construction might be desirable as it tends to lower the cost. The earth excavated from the trench may be used to provide the sides of the silo for the above-ground portion.

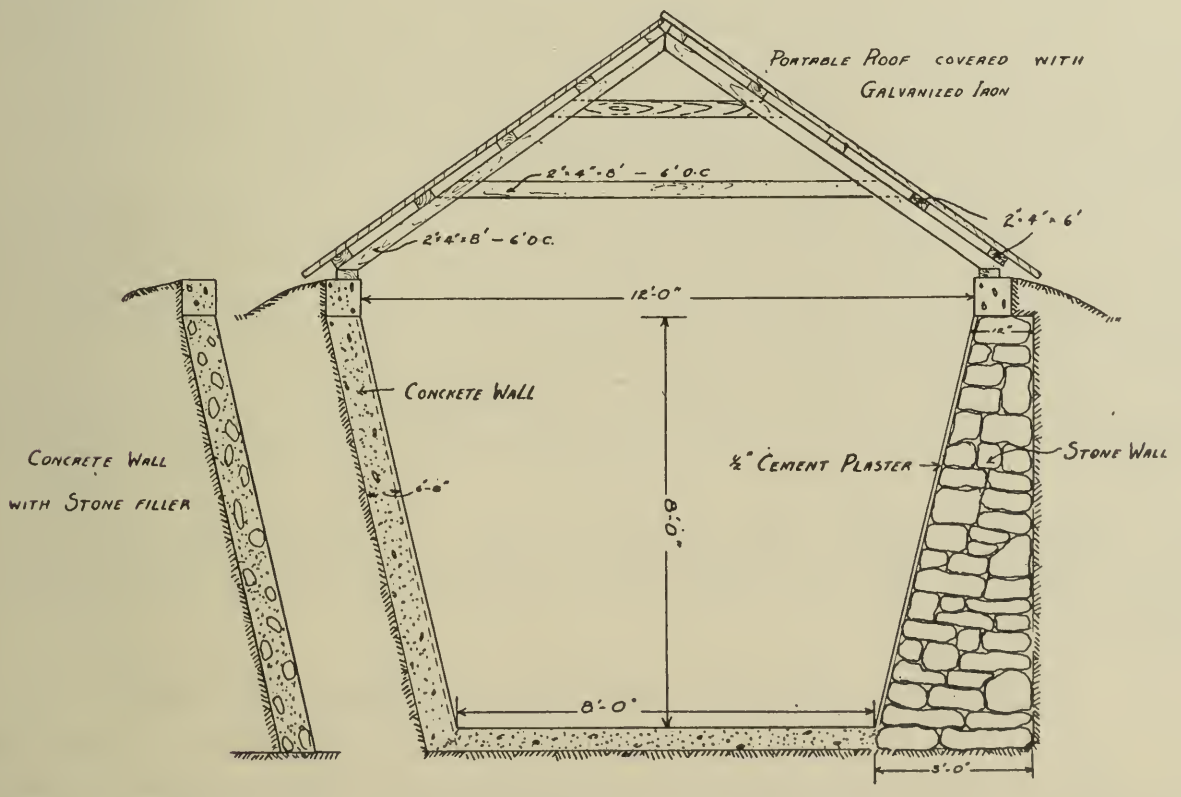

Fig. 2.—Diagram of trench silo showing three types of wall construction and portable roof built in sections.

Roof for Trench Silo

While a roof on a trench silo is not absolutely essential it is very convenient and has some value in protecting the silage. It protects the silage from rain and snow and eliminates the necessity of shovelling off snow when removing the silage. If the silo is located adjacent to the barn with a connecting doorway the silage may be taken from the silo to the stable without

going out of doors. The roof may be of very simple construction such as of logs, wire and straw as illustrated in figure No. 1. The material for this type of roof can usually be found on the average farm and does not involve any cash outlay.

A more substantial and very convenient roof may be built in sections about 6 or 8 feet long and the width of the silo. The frame may be of lumber or poles covered with galvanized iron. The sections may be easily removed for filling and conveniently replaced when the silo is full.

Filling the Trench Silo

Less power is required for the ensilage cutter with the trench silo as the material does not have to be elevated so high but may be blown directly into the trench. It is suggested that an ordinary small cutting box be used with 11-inch knives. No blower is necessary as the silage simply drops into the trench. This cutter may be operated by a small 4- or 5-horsepower gasoline engine or electric motor. It has a capacity of 3 to 4 tons per hour and by means of this outfit two men could fill the silo and eliminate the expense of the large gang of men usually required.

With the comparatively recently developed Ronning Corn Harvester which cuts the corn into silage length in the field and delivers it into a wagon box drawn alongside the machine, the trench silo is very convenient. With this method the silage may be drawn from the field and dumped from the wagon directly into the trench silo.

Whatever method is employed it is absolutely necessary to distribute the silage evenly throughout the silo and tramp it thoroughly. The tramping is usually accomplished by driving a horse, a team of horses or a tractor back and forth over the silage. This tramping is extremely important as there is much less pressure in the trench silo than in the tall upright silo. If the air is not excluded by thorough tramping the silage is likely to spoil.

Some success has been reported where the crop is ensiled in the trench silo without cutting into short lengths as is the usual custom. Where corn is used the sheaves are laid in the silo lengthwise in layers and after the sheaf is put in place the band is cut. The material is then tramped thoroughly, this work being even more important with the uncut material than where it is cut. In view of the liability of failure this method is not recommended.

When the silo is full it should be sealed in some way to prevent spoilage on the surface. This may be done most conveniently by covering the whole mass with 6 to 8 inches of cut straw, hay or chaff. This should be soaked with water and tramped thoroughly for a few days.

The silo should be opened at one end and the silage removed in vertical slices. Slices at least two inches thick should be fed off each day in order to prevent spoilage.

CHEMICAL ANALYSIS AND PALATABILITY OF SILAGE

Chemical analyses have been made of representative samples of silage from the various crops, the samples being taken from the small one-half ton experimental silos at the time of opening for feeding purposes. The results are a record therefore, of the nutrients contained in the feed as silage and are typical of what may be expected in the various crops at the completion of the ensilage processes. Determinations have been made of moisture, acidity, protein, fat, carbohydrates, fibre and ash. The analytical work was undertaken by the Division of Chemistry, Science Service, Ottawa.

The palatability of the various silages was determined by feeding the material to groups of dairy cows which were provided by the Division of Animal Husbandry. Enough silage was fed daily along with other feed to supply

a ration for two cows for a period of about 8 days. The observations were based upon the apparent relish with which the cattle ate the silage. If they ate it greedily, the palatability of the silage was termed excellent. From this standard of excellence it was graded down through good, fair, poor and that which was unfit for feed. It may be noted that the odour of the silage was not always an accurate guide to its relative palatability and occasionally silage which was agreeable to the human sense of smell was not relished by the cattle. Similarly in a few instances silage with a rather disagreeable odour was eaten by the cows with apparent relish. In general, however, odour is a fairly good indication of quality.

MOISTURE CONTENT OF SILAGE VERY IMPORTANT

The moisture content of the crops to be ensiled plays a very important role in the quality of the silage. In almost every instance where the silage was rated lower than good, the material was either comparatively low or high in moisture content. Where it was too high sour silage or rotting took place while where it was too low the material was usually musty or mouldy.

Corn produces good silage even when it contains a comparatively high percentage of moisture. The average content of moisture in good corn silage in these experiments was 78 per cent. Good silage was produced, however, with corn ranging from 69·86 to 81·20 per cent moisture. Below 69·86 per cent in three instances the silage was of inferior quality. About 75 per cent moisture is ideal for corn silage, but good silage may be produced with a moisture content 5 per cent above or below this amount. Under normal conditions corn cut in the glazed or dough stage of maturity will contain the ideal moisture content.

A mixture of oats, peas and vetches should contain about 70 per cent of moisture for best results. Good results have been obtained with material above and below this amount but care should be taken to have the moisture range between 65 and 75 per cent. This desirable moisture content may be obtained if the crop is cut when the oats are in the early dough stage. Under very humid conditions or where the crop has lodged badly it might be advisable to allow the crop to wilt for about five hours after cutting, before ensiling.

Red clover will produce good silage under a wider range of moisture content than oats, peas and vetches. Good silage has been produced with the crop ranging in moisture content from 58·40 per cent to 81·90. An attempt should be made, however, to ensile when the moisture content is about 70 per cent which is usually when the red clover has reached full bloom. No wilting should be required.

Alfalfa requires greater care in ensiling than almost any other crop. Although good silage was produced within a range of 61·50 to 75·20 per cent moisture in alfalfa in eight instances a low quality of silage was produced when the moisture content was above 75·50 per cent and in three instances poor silage was produced when the moisture was below 65 per cent. The aim should be to ensile alfalfa with a moisture content of 70 per cent and it would be safer to go slightly below rather than above this amount.

Sweet clover will carry a high moisture content more satisfactorily than most other legumes and like red clover makes good silage under a wide range of conditions. About 70 to 75 per cent moisture is most suitable for sweet clover silage, this condition being obtained by cutting the crop when about one half the blossoms have appeared. A small amount of wilting is not detrimental.

Table 17 shows the amount of moisture, stage of maturity, and wilting necessary, under normal conditions, to produce an excellent quality of silage of various crops. When the best stage of maturity to cut is said to be "full-bloom" it means when the crop just reaches the full-bloom stage.

TABLE 17—MOISTURE CONTENT, STAGE OF MATURITY AND TREATMENT NECESSARY FOR ENSILING VARIOUS CROPS

Crop	Most suitable moisture content per cent	Stage of maturity at which to cut	Treatment after cutting the crop
Alfalfa	70·00	Full-bloom	Wilt at least 5 hours
Alsike	70·00 to 75·00	Full-bloom	Ensile immediately
Artichoke (tops)	70·00	Full-bloom	Ensile immediately
Buckwheat	75·00	Full-bloom	Wilt at least 5 hours
Barley	75·00	Milk to dough	Ensile immediately
Corn	75·00	Firm dough	Ensile immediately
Kale	80·00	Fully grown	Wilt slightly
Millet	75·00	Full-bloom	Ensile immediately
Oats, peas and vetches	70·00	Oats in early dough	Ensile immediately
Oats	75·00	Milk to dough	Ensile immediately
Red clover	70·00	Full-bloom	Ensile immediately
Sweet clover	70·00 to 75·00	One-half-bloom	Ensile immediately
Soybeans	70·00	Seed well formed	Ensile immediately
Soybeans and corn	70·00 to 75·00	Corn in dough; soybean seeds well formed.	Ensile immediately
Sunflowers	60·00 to 75·00	One-half-bloom	Ensile immediately
Timothy	70·00	Full-bloom	Ensile immediately

ACIDITY OF SILAGE

The relative amounts of acidity developed in the silage from various crops seems, within certain limits, to have little bearing upon the quality of the silage. A certain degree of acidity is developed in a good quality of silage inasmuch as organic acids are largely responsible for the preserving or keeping quality. The acidity will vary considerably with different crops. A higher acidity is usually found in corn than in legume silage. The addition of molasses to legumes promotes the development of acids. It has been found where silage of good quality has been produced, the pH of timothy ensiled before heading was 5·1. With molasses added it was 4·6. Red clover silage had a pH of 5·4 and with molasses added 4·4. In alfalfa silage a pH of 5·6 was produced and with molasses added the pH was 4·8. The pH of good corn silage is 3·7.

PROTEIN AND CARBOHYDRATES IN SILAGE

Crops which are high in carbohydrates are most easily made into satisfactory silage. Some crops high in protein and comparatively low in carbohydrates produce good silage only when the proper methods of ensiling are followed. This does not necessarily mean that all crops with high carbohydrates contents make ideal silage. In fact, such silage does not afford a well balanced ration in that it is low in protein, the most expensive part of the feed. The carbohydrates, however, contain the starches and sugars which play such an important part in the processes which are responsible for the preservation of the silage.

Corn, sunflowers, kale and certain other crops are high in carbohydrates and are easily ensiled. Legume crops, such as alfalfa, alsike and sweet clover, are comparatively low in carbohydrates but high in protein. Greater precaution is necessary in making silage from these crops. Alfalfa presents the greatest difficulties in silage making.

Although the amount or relative proportion of the various constituents undoubtedly plays an important part in the production of good silage, satisfactory feed may be produced from crops which depart from the optimum composition, provided other undesirable factors are eliminated. Corn is recognized as the ideal silage crop where it can be grown successfully. However, it is low in protein and while increasing the livestock carrying capacity of a farm necessitates the purchase of high protein supplementary feed which unfortunately is expensive. It is possible by mixing a small proportion of a legume or high

protein crop with corn, a good silage and a better balanced feed may be produced than where corn alone is used. A good example of this is the mixture of one part of soybeans or clover and three parts of corn. Similarly, additions of timothy, corn, crude sugar, molasses or other material high in carbohydrates improves the quality of alfalfa and other high protein crops.

WEIGHT OF SILAGE PER CUBIC FOOT

It is impossible to state definitely the actual weight of silage per cubic foot which will apply under all conditions. Many factors influence such a weight, chief of which being; (1) crop used for silage; (2) moisture content; (3) proportion of grain to fodder; (4) rate of filling the silo; (5) amount of settling; (6) depth of silo; (7) diameter of silo; (8) distribution of material in the silo; (9) thoroughness of packing.

Table 19 shows a comparison of the weight of corn silage per cubic foot as measured by investigators at several institutions. The weights given are the average weight per cubic foot to the depth indicated.

TABLE 19—AVERAGE WEIGHT OF SILAGE PER CUBIC FOOT TO DEPTH INDICATED

Depth of silage, feet	Nebraska unsettled	Wisconsin settled 2 days	Kansas and Missouri settled 1 month	Ottawa settled 1 to 6 months
	lb.	lb.	lb.	lb.
1	16·1	18·7	32·0	.....
2	16·9	19·6	32·4	30·3
3	17·6	20·6	32·7	30·7
4	18·4	21·2	33·1	31·1
5	19·1	22·1	33·4	.....
6	19·8	22·9	33·7	30·8
7	20·5	23·8	34·1	.....
8	21·2	24·5	34·4	.....
9	21·9	25·3	34·7	31·6
10	22·6	26·1	35·0	32·8
11	23·3	26·8	35·3	35·4
12	23·9	27·6	35·6	35·0
13	24·6	28·3	35·9	36·1
14	25·2	29·1	36·2	37·0
15	25·9	29·8	36·4	37·6
16	26·5	30·5	36·7	38·6
17	27·1	31·2	36·9	39·0
18	27·8	31·9	37·1	39·1
19	28·4	32·6	37·3	39·6
20	29·0	33·3	37·5	40·3
21	29·6	33·9	37·6	40·9
22	30·2	34·6	37·8	41·2
23	30·7	35·3	38·0	41·4
24	31·3	35·4	38·1	41·2
25	31·8	36·5	38·3	42·3
26	32·4	37·2	38·4	42·8
27	32·9	37·8	38·6	42·7
28	33·4	38·4	38·7	42·9
29	33·9	39·0	38·9	43·2
30	34·4	39·6	39·0	43·6
31	34·9	40·1	.....	43·6
32	35·4	40·7	.....	43·9

Considerable variation will be observed in the weights of silage as reported by various Experimental Stations. This variation may be explained by the fact that the weights have been taken under different conditions and the various factors previously mentioned may have produced somewhat different results. It will be noted, in each case, that the length of settling has been different. The Kansas and Missouri, and Ottawa figures are perhaps more comparable from this standpoint and to depths of about 16 feet they check very closely although some considerable variations occur at the lower depths. These differences may be

accounted for by the different lengths of period ensiled and perhaps to a greater extent by the moisture content. The average dry matter in all the trials at Kansas and Missouri was 35·2 per cent whereas at Ottawa the average was only 21·28. The drier material in the Kansas and Missouri trials would naturally weigh less than that used at Ottawa.

CAPACITY OF SILOS

It will be realized that with so many factors influencing the weight of silage per cubic foot it is impossible to present an accurate table showing the actual capacity of different sized silos. Any table which may be presented, therefore, should be used only as an approximate estimation. An estimate is useful, however, when building a new silo in order to know the size necessary to hold sufficient silage for a certain number of animals. It is sometimes useful, also, to estimate the amount of silage left in a silo after part has been fed. This might be necessary in the event of a sale or to determine the amount of silage available for a certain feeding period.

TABLE 20—TONS OF CORN SILAGE AT TIME SILO IS FILLED AND WITHOUT REFILLING*

Inside diameter in feet	Depth of silage in feet													
	8	10	12	14	16	18	20	22	24	26	28	30	32	34
10	7	9	11	14	17	20	23	26	29	33	37	41		
12	10	13	16	20	24	28	33	38	42	48	53	58	64	70
14	13	17	22	27	33	38	45	51	58	65	72	79	87	95
16	17	23	29	35	43	50	58	67	75	85	94	104	114	124
18	22	29	37	45	54	64	74	84	96	107	119	132	144	157
20	27	35	45	55	67	79	91	104	118	132	147	162	178	194
22	32	43	55	67	81	95	110	126	143	160	178	196	215	235
24	38	51	65	80	96	113	131	150	170	190	212	234	256	279

* Add approximately 30 per cent to above tonnage if silo is refilled.

Obviously, in estimating the capacities of silos under settled and unsettled conditions two tables are necessary. For unsettled silage the Nebraska figures give a fairly close guide, and these are shown in table 20 and are based on the assumption that the silage is in a normal condition when put in the silo, that the silo is filled without delay, and that two men are kept in the silo tramping. This table may be used in estimating the capacity of a silo in tons and should give an approximate guide to the size necessary for different requirements.

It must be observed, however, that if the silage is allowed to settle one or two weeks and then more crop added, the silo will hold considerably more than is shown in table 20. If it is again allowed to settle more silage may be added. Possibly under such circumstances the table of capacities shown in table 20 should be increased approximately 30 per cent.

TABLE 21—TONS OF CORN SILAGE IN SILOS AFTER SETTLING ONE TO SIX MONTHS

Inside diameter in feet	Depth in feet												
	10	12	14	16	18	20	22	24	26	28	30	32	34
10	13	16	20	24	28	32	36	39	43	47	51	55	60
12	18	24	29	35	40	46	51	57	62	68	74	79	86
14	25	32	40	47	55	62	70	77	85	92	101	108	117
16	33	42	52	62	71	81	91	101	111	121	131	140	153
18	42	53	66	78	89	102	115	128	140	153	166	179	193
20	51	66	81	97	110	127	142	158	173	189	205	221	239
22	62	80	98	117	134	153	172	191	209	228	249	267	289

Table 21 shows the amount of silage contained in silos of various dimensions after settling from one to six months. The capacities are based on average weights of cubic foot volumes of silage taken from three silos at Ottawa in 1929 and 1930 as shown in table 19. The silos consisted of one vitrified tile silo 22 feet in diameter and 35 feet high, one cement block of the same size and one stave silo 18 feet in diameter and 32 feet high. This table may be used in estimating the amount of settled silage in a silo.

As the weights in table 21 are based on the average weight per cubic foot from the top of the silage to the depth indicated, the amount of silage left in a silo after a certain portion has been fed out must be calculated by determining the total amount of settled silage originally in the silo and subtracting from it the amount which has been removed. The remainder is the amount still left in the silo.

The above weights will be too high for corn with a low moisture content. As mentioned before the average moisture content of the corn from which the above weights were prepared was 21·28 per cent. Similarly the other factors mentioned on page 74 will tend to raise or lower the above weights.

AMOUNT OF SILAGE TO FEED

In order to determine the required amount of silage to produce it is necessary to estimate the requirements of different classes of livestock. A dairy cow may be fed 20 to 40 pounds of silage per day depending upon the size of the cow and

At least two inches of silage should be fed each day from the silo in order to prevent spoilage. For this reason high silos with small diameter are preferable to large silos.

the amount of milk produced. Beef cows will require 30 to 50 pounds, fattening 2-year-old steers 25 to 40 pounds, breeding ewes 1½ to 3 pounds and fattening lambs 1 to 2½ pounds per day. Brood mares and idle horses may be fed 10 to 15 pounds per day.

Silage is used chiefly as feed for dairy and beef cattle. Small amounts may be successfully fed to other classes of livestock. The amounts recommended above are based on corn silage. Silage made from oats and peas, red clover, alfalfa, sweet clover and other leguminous plants should be fed in somewhat smaller amounts than those mentioned.

AMMOUNT OF SILAGE AND ACREAGE REQUIRED FOR HERDS OF VARIOUS SIZES

It is useful to calculate the total amount of silage necessary during the feeding season and the acreage of land required to grow this silage. It may be assumed that the majority of silage grown is fed to cattle and as a basis for calculations 30 pounds per day per animal unit, or per cow weighing 1,000 pounds, or the equivalent in other animals might be used. It may be assumed also that silage is fed only for the winter months from November to May or approximately 200 days. The average yield of corn silage per acre might be set at 10 tons which, while slightly higher than the average yield for Eastern Canada, approximates the yield throughout the province of Ontario. On the Central Experimental Farm, Ottawa, however, the average annual yield of corn is 16 tons per acre. On the basis of a yield of 10 tons per acre and feeding 30 pounds of silage per day, table 22, showing the tons of silage required and acreage necessary has been calculated.

TABLE 22—AMOUNT OF CORN SILAGE AND ACREAGE REQUIRED FOR HERDS OF VARIOUS SIZES

Number of animal units	Tons of silage required for 200 days feeding	Acreage required to grow silage crop yielding 10 tons per acre	Number of animal units	Tons of silage required for 200 days feeding	Acreage required to grow silage crop yielding 10 tons per acre
8	24	2·4	26	78	7·8
10	30	3·0	28	84	8·4
12	36	3·6	30	90	9·0
14	42	4·2	32	96	9·6
16	48	4·8	34	102	10·2
18	54	5·4	36	108	10·8
20	60	6·0	38	114	11·4
22	66	6·6	40	120	12·0
24	72	7·2			

REMOVAL OF SILAGE FROM THE SILO

Silage spoils very readily when exposed to the air. When feeding silage, therefore, it is necessary to remove a sufficient quantity each day to prevent spoilage on the top. In order to prevent this spoilage it is necessary to remove at least two inches per day in winter feeding. For summer feeding even more should be used daily. Care should be taken in building the silo so that the diameter is in relation to the size of herd in order to allow for feeding off the necessary amount of silage each day. A square foot area two inches deep near the top of the silo weighs approximately 5 pounds. Towards the bottom a similar volume weighs about 7 pounds. The average weight may be taken, therefore, as 6·5 pounds. On this basis table 23 has been prepared showing the amount of silage in a two inch depth, in silos of various diameters, and the size of herd, in animal units, necessary to consume this amount of silage assuming a consumption of 30 pounds of silage each per day.

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TABLE 23—AMOUNT OF SILAGE IN TWO-INCH DEPTH IN SILOS OF VARIOUS DIAMETERS

Diameter of silo, feet	Pounds of sileage in 2-inch depth	Number of animal units necessary to consume silage	Diameter of silo, feet	Pounds of silage in 2-inch depth	Number of animal units necessary to consume silage
9	409	14	15	1149	38
10	510	17	16	1307	44
11	617	21	17	1476	49
12	735	24	18	1654	55
13	863	29	19	1843	61
14	1001	33	20	2045	68

It will be seen from the above table, therefore, that in a silo 10 feet in diameter it is necessary to feed off 510 pounds daily in order to remove 2 inches of silage and that to consume this silage there would be required approximately 17 animal units. With a silo 20 feet in diameter 68 animal units would be required. From this table, therefore, it is possible to determine the correct diameter of silo for different requirements. Knowing the length of the feeding period and the total amount of silage necessary for this period, it is possible to compute the height of the silo from the table of capacities on page 22. A comparatively high silo with small diameter is usually preferable to a low silo having a large diameter.

SUMMARY

1. Silage is used very extensively in some provinces of Canada, especially in Ontario and in parts of Quebec and British Columbia. While a few farmers in certain districts have discontinued the use of their silos, chiefly on account of the labour and expense involved, this tendency is not general. Where corn grows successfully, it produces a large yield even in seasons unfavourable to other crops and affords an insurance against feed shortage. In districts unfavourable to corn production, other crops may be ensiled successfully. Silage, moreover, provides excellent succulent feed.
2. On account of the wide difference in soil and climatic conditions throughout Canada, it is natural that certain districts are more favourable to silage production than others. This bulletin gives the recommendations of the superintendents of the Dominion Experimental Farms located in representative regions throughout Canada on the adaptability of the silo and the most suitable crops for their respective districts.
3. While corn is very readily ensiled, certain other crops may produce very poor silage unless proper methods are employed. Alfalfa, for example, if ensiled when one-tenth in bloom as recommended for hay often produces silage unfit for feed while when ensiled at the full-bloom stage gives excellent results. This bulletin presents information based on extensive experimental work on the Dominion Experimental Farms on the most efficient methods of ensiling, as well as growing some 20 different farm crops.
4. The acid treatment of ensiling crops is a new method which has been introduced in recent years in Europe. It consists in adding a small percentage of dilute mineral acids at the time of ensiling. The advantages claimed for this method are that undesirable fermentation, the respiration of the plant cells, and the action of the proteolytic enzymes in splitting up nitrogenous compounds are prevented. This results in the conservation of the forage without appreciable loss, the colour and odour of the silage resembling that of the crop at the time of cutting and the palatability, especially of

such a crop as alfalfa being somewhat improved. Some inconvenience and expense, however, are involved with this treatment so that further experiments are necessary before definite recommendations may be made.

5. The relative advantages of root and silage crops is a subject on which considerable difference of opinion exists. Information is presented from Dominion Experimental Farms in Eastern Canada on the comparative yields, cost of production and value of root and silage crops based on the amounts of total digestible nutrients.
6. A brief description is included of the different types of upright and trench silos. Information is presented on the construction and approximate cost.
7. Information is presented on the chemical analysis of silage made from various crops, the capacity of different silos and the amount of silage and acreage required for various sizes of herds.